THE FIRST GREAT DEVONIAN FLOODING EPISODES IN WESTERN NEW YORK: REEXAMINATION OF UNION SPRINGS, OATKA CREEK, AND SKANEATELES FORMATION SUCCESSIONS (LATEST EIFELIAN – LOWER GIVETIAN) IN THE BUFFALO-SENECA LAKE REGION

Baird, G.C., Department of Geosciences, State University of New York College at Fredonia, Fredonia, New York 14063; Brett, C.E., Department of Geology, University of Cincinnati, 500 Geology/Physics Building, Cincinnati, Ohio 45221; Ver Straeten, C., Department of Geology, University of Wisconsin: Oshkosh, Oshkosh, Wisconsin 54901

INTRODUCTION

The lower (sub-Ludlowville Formation) part of the Hamilton Group in western New York has received little attention by geologists owing to poor exposure and to the perception that it is composed essentially of drab, unfossiliferous deposits. Reexamination of numerous sections and several subsurface cores of Onondaga Group and lower Hamilton Group strata by Brett and Ver Straeten (1994) and Ver Straeten et al. (1994) has led to significant revisions of published correlational schemes (Rickard, 1975, 1984). In particular, the old formational division of the lower Hamilton Group (Marcellus Formation) has been elevated to subgroup status and is now understood to include two formational entities (Ver Straeten et al., 1994); the Union Springs Formation (Bakoven Member-Hurley Member-succession) comprises the lower part of the Marcellus subgroup and the Oatka Creek Formation (Cherry Valley Member through Chittenango Member-succession) represents the upper part (Fig. 1). The above terminology of Ver Straeten et al. (1994) is employed herein (Figs. 1, 2). Two of us (Baird, Brett) are involved in ongoing revision of the Union Springs-through-Skaneateles formational successions across central and western New York as, well as central Pennsylvania. Only a small portion of this work has yet been set in print; Meyer, working under supervision of Baird, revised the stratigraphy of the Stafford Member (basal Skaneateles Formation) and elucidated its relationship with the Mottville Member (Meyer, 1985). A spectacular erosionally furrowed discontinuity surface (see STOP 6) has been described from the lower medial part of the Levanna Member in Erie County (Brett and Baird, 1990; Baird and Brett, 1991). The stratigraphic relationships of basinal Chittenango Member and Levanna Member facies in western New York with coarser, shoreward deposits in central New York are the subject of detailed scrutiny by Brett and Baird.

The present paper advances an overview of the stratigraphy of the topmost Onondaga Group and sub-Centerfield Hamilton interval between the Seneca Lake meridian and Lake Erie noting revisions to date. We also tentatively explain vertical and lateral lithologic changes in terms of an inferred sea level curve and the sequence stratigraphy paradigm. Key background sources on the stratigraphy of this interval by earlier workers include: Cooper (1930); Smith (1935); Rickard (1975, 1984); Grasso (1986); Linsley (1991); Brower and Nye (1991); Brett and Ver Straeten (1994); and Ver Straeten et al. (1994). Because the Union Springs, Oatka Creek, and, especially, the Skaneateles

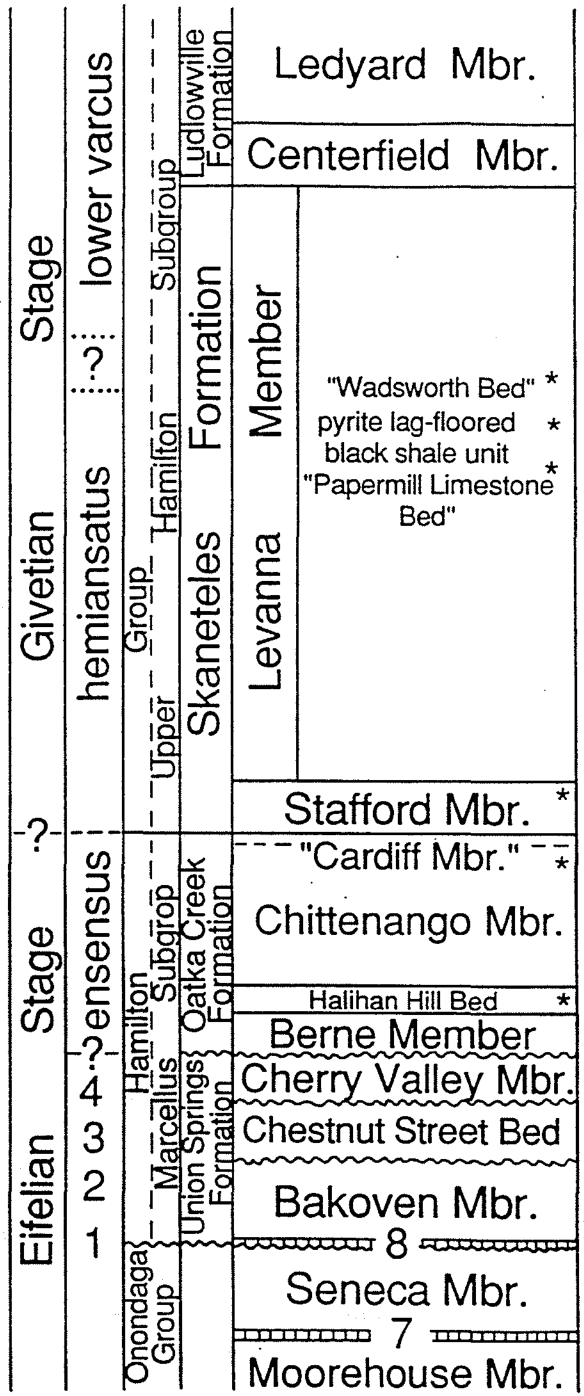

Figure 1. Generalized succession of lithologic and zonal units in the uppermost Onondaga Formation-through-basal Ludlowville Formation interval in western New York. Numbers denote: 1, base-Bakoven Member discontinuity; 2, *Cabrieroceras plebieforme* zone; 3, *Haplocrinites* zone; 4, *Agoniatites vanuxemi* zone; 7, Onondaga Indian Nation (OIN) K-bentonite; 8, Tioga "F" K-bentonite.

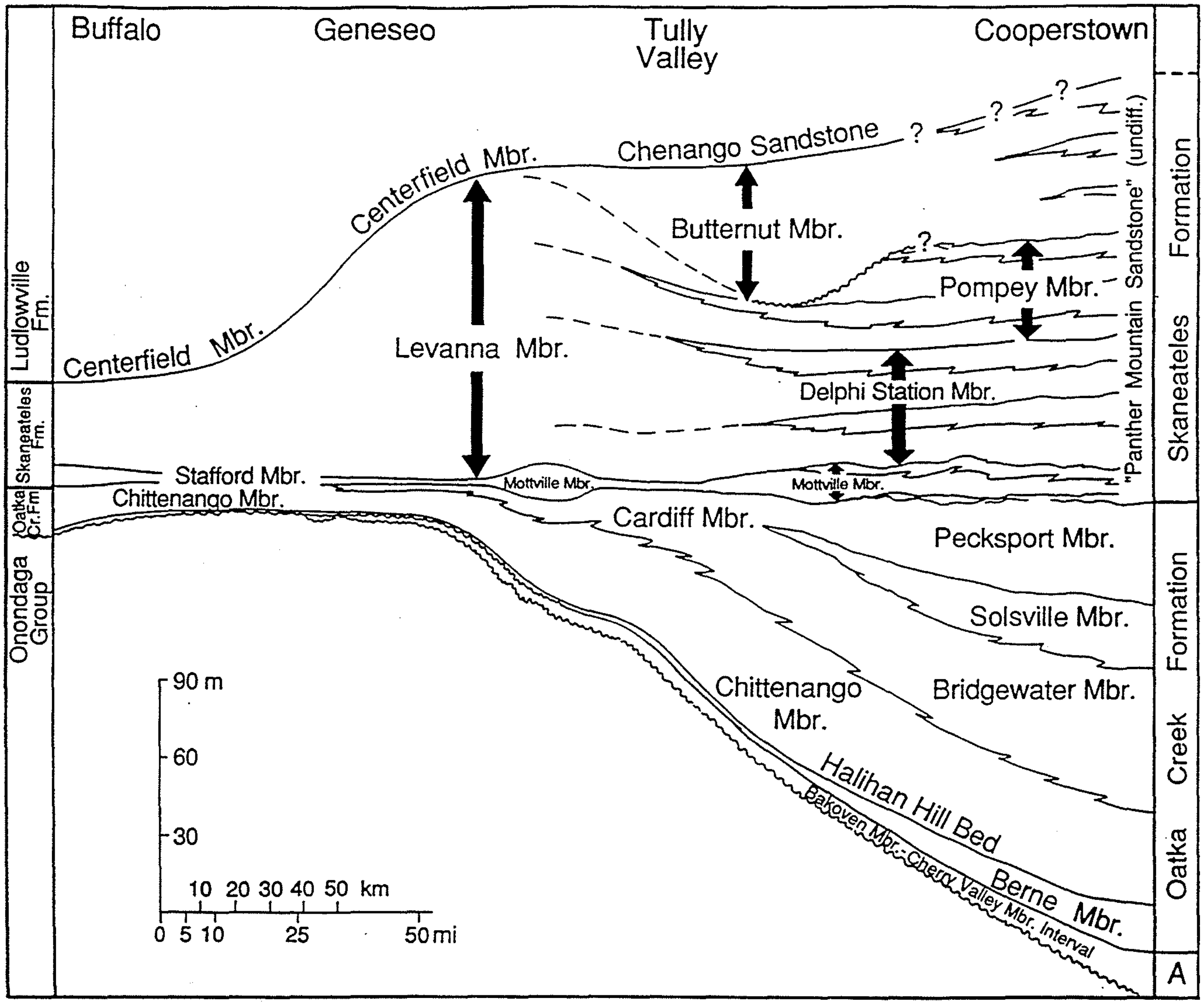

Figure 2. Generalized stratigraphy and unit relationships in the lower part of the Hamilton Group along the east-west outcrop belt across New York State. Conspicuous eastward thickening of units reflects major clastic influxes associated with the second tectophase of the Acadian Orogeny and coincident deepening of the Devonian foreland basin.

formational successions are poorly exposed, we can only focus on a few key beds and distinctive intervals in the present report.

STRATIGRAPHIC-HISTORICAL OVERVIEW

Onondaga Group and Union Springs Formation

The uppermost Emsian?-Eifelian Onondaga Group records a subtidal carbonate shelf supportive of a variably diverse open marine biota comprising the "Onondaga Fauna" (see Oliver, 1956, Koch, 1981; Brett and Ver Straeten, 1994). Epeirogenic processes, presumably linked to the ongoing Acadian Orogeny in New England (Ver Straeten et al. 1994) explain a pattern of an eastwardly migrating backbulge basin within the medial Onondaga Limestone across western New York (Brett and Ver Straeten, 1995). In Pennsylvania, to the south of the Finger Lakes, Onondaga deposits accumulated in a carbonate-starved deeper part of the foreland basin under conditions that were more decidedly dysoxic (Koch, 1981; Brett and Ver Straeten, 1994).

The end of Onondaga carbonate deposition, marked by packstone to lime mudstone facies of the Seneca Member, signaled the onset of a major deepening event within the Appalachian Basin, designated the "second tectophase" by Ettensohn, 1985, 1987; widespread deposition of organic-rich shales and ribbon limestones of the Bakoven Member of the Union Springs Formation marks the presumed collapse of the carbonate platform due to a major thrust loading pulse associated with terrain collision to the east. This was closely associated with the progradation of clastics from orogenic source areas to the east; the developing foreland basin was filled with sediment as it subsided and expanded leading to the long-recognized pattern of eastwardly thickening clastic wedges within the Hamilton Group (Fig. 2). Significantly, the post-Onondaga deepening event is closely associated with the "Tioga" cluster of k-bentonites that occur both within the upper Onondaga and basal Union Springs successions. Rapid eastward-southeastward thickening of the Bakoven shale in the vicinity of the Hudson Valley attests to initial development of foreland basin conditions timed with earliest Hamilton Group deposition (Ver Straeten et al., 1994).

The Union Springs Formation marks an initial major flooding pulse partly of tectonic and partly of eustatic origin (see Ettensohn, 1985, 1987; Ver Straeten et al., 1994). Above the Bakoven Member interval, however, is evidence of a regression marked by the Stony Hollow Member-Chestnut Street Bed-interval (Ver Straeten et al., 1994) which is mostly eustatic origin but is influenced by the first coarse clastic pulse of the Hamilton succession. The thin Chestnut Street Limestone submember ("proetid bed") of the Hurley Member originally lumped within the Cherry Valley Member (Rickard, 1975; Cottrell, 1972), is now observed to be a distinct unit from the overlying Cherry Valley (Fig. 1). This bed, is the condensed cratonward equivalent of the much thicker, siliciclastic succession of the Stony Hollow Member in the Hudson Valley (Ver Straeten et al., 1994). Moreover, the Cherry Valley Member, "*Agoniatites* Limestone" of early workers, is observed to be a thin (condensed) transgressive drape over the top of the Stony Hollow Member in eastern Mohawk Valley and Hudson Valley sections (Ver

Straeten et al., 1994). Thus the Bakoven-Stony Hollow-Chestnut Street succession respectively correspond to late highstand-regressive parts of the first great Hamilton sedimentary cycle, while the Cherry Valley marks the basal transgressive deposit of the second major cycle.

The Union springs cycle also marks an incursion of a new faunal association that replaces the long-standing "Onondaga Fauna". This faunal change was part of a global or near-global series of bioevents termed "Kacak-otomari" events by Chlupac and Kukal, 1986; Walliser, 1986; Truyols-Massoni et al., 1990 which are believed to be linked to a sea level highstand event timed with the late Eifelian. Distinctive taxa including: *Variatrypa arctica*, *Pentamerella winteri*, *Schizophoria* Sp., and *Emmanuella* Sp. characterize the Union Springs Formation. Kacak-Otomari immigrants are believed to be linked to warmer tropical water sources, perhaps in paleoenvironments recorded in deposits in present day arctic Canada.

Oatka Creek Formation

The Oatka Creek Formation, dominated by organic-rich basinal facies in central and western New York, records expansion of the foreland basin during the earliest Givetian. (Figs 1,2). A brief but widespread incursion of globally important cephalopods and dacryoconariids (Chlupac and Kukal, 1986; Walliser, 1986; Ver Straeten et al., 1994; Griffing and Ver Straeten, 1991) is reflected in the transgessive Cherry Valley facies. The Eifelian-Givetian zonal boundary probably lies slightly above the Cherry Valley Member-Berne Shale Member contact across the study area. The Berne Member, marked by a very thin, condensed interval of black, styliolinid-dacryoconariid-rich black shale in central and western New York, records a major highstand event (Ver Straeten et al., 1994). In western New York it is only 0.3-1.5 m-thick but thickens dramatically in Hudson Valley localities attesting to a depocenter in that region.

The Berne Member is succeeded by the widespread thin (0.5-1.0 m-thick) Halihan Hill Bed which marks the dramatic appearance of the long-standing "Hamilton fauna," an endemic "cooler water" biota characteristic of much of the Appalachian basin Givetian succession (Ver Straeten et al., 1994. The Halihan Hill Bed, originally discovered by Clelland (1903) and termed the "first *Meristella* Bed" in the Cayuga Valley and later rediscovered in several western New York localities, but not formally named, by Baird during the 1980s, is named for an occurrence 100 m above the base of the Berne Member at Halihan Hill near Kingston (Griffing and Ver Straeten, 1991; Ver Straeten et al., 1994). The Halihan Hill Bed, marking a major regression, yields a diverse biota locally characterized by large corals in the Hudson Valley. Key first appearances of the Hamilton fauna include: *Phacops rana, Microcyclus, Mediospirifer, Tropidoleptus*, and *Meristella;* in addition a number of Onondaga lineages reappear, e.g., *Heliophyllum*, *Heterophrentis*, and *Athyris*. This unit abruptly overlies the Berne Member and is herein defined as the base of the Chittenango Member in western and central New York and the equivalent Otsego Member in eastern New York. The condensed nature of the Halihan Hill Bed is widespread and striking.

Examination of Cooper's (1930) Chittenango type section, near Cazenovia, NY demonstrated that the lowest well exposed beds are styliolinid-rich limestones associated with the Halihan Hill bed. Thus, we define the term "Chittenango" as including the Halihan Hill bed and all overlying black, organic-rich shale up to the gray Cardiff beds; we also extend the member name into western New York where the Chittenango encompasses most of the Oatka Creek formation.

The Chittenango Shale Member comprises the bulk of the Oatka Creek Formation thickness across western and west central New York (Fig. 2). This unit is remarkable for its elevated (up to 18%) total organic carbon content (Ver Straeten pers. comm.). Both the Bakoven and Chittenango members display high T.O.C. levels and are highly radioactive markers on gamma ray logs (Rickard, 1984). In fact, these units display the highest geochemical signals for anoxia known for the Devonian of eastern North America. In the area of the field trip excursion the Chittenango Member averages 10 m-thickness. In eastern New York, this interval expands to 500 m or more in thickness as the black shale facies passes laterally to gray mudstone, nearshore sandstone facies and red beds.

The uppermost 1-3 m of the Chittenango interval below the Stafford Member of the Skaneateles Formation in the field trip area is composed of fissile medium gray to dark gray mudstone yielding a sparse biota of small *Eumetabolotoechia* ("*Leiorhynchus*") *limitare*, flattened orthoconic nautiloids, the bellerophontid *Retispira* and styliolines. This division, is believed to be equivalent to the Cardiff Member in central New York. It records dysoxic, outer shelf conditions intermediate between the anoxic Chittenango Member and the overlying Stafford Member.

Skaneateles Formation

The laterally equivalent and coextensive Stafford Member (western New York) and Mottville Member (central New York) successions mark a regressive interval at the base of the Skaneateles Formation. The Stafford succession in Genesee, Livingston, and Ontario County, consists of a single 20-50 cm-thick falls-capping limestone bed underlain by approximately 0.5 m of calcareous dark gray shell-rich, fissile shale and overlain by about a meter of calcareous dark gray mudrock with sparse fauna. The basal shale interval abounds in the brachiopods *Ambocoelia umbonata, Longispina, Productella,* and *Truncalosia truncata*, flattened orthoconic nautiloids and small benthic molluscs. The hard limestone contains small rugose and auloporid corals, the gastropod *Bembexia sulcomarginata*, three-dimensional orthocones, *Ambocoelia*, and small benthic molluscs. The upper shales contain *Ambocoelia*, orthocones and small molluscs.

In Erie County, the Stafford thickens to 4 m total thickness at Como Park (STOP 5) and acquires minor lentils of chert in its upper part (Meyer, 1985; Brett and Baird, 1990). Further west, at Buffalo Creek, the Stafford continues to thicken and it becomes distinctly cherty. In this region, the main limestone portion of the Stafford yields abundant small *Phacops rana*, scattered pelmatozoan columnals and molluscan debris (Meyer, 1985). Throughout western New York, the fauna of the main limestone bed is of only moderate diversity, recording minimally oxic conditions. The higher shale unit marks an upward transition to anoxia recorded in the basal part of the Levanna Shale Member.

Across Cayuga and Onondaga counties, the Stafford thickens eastward as it grades laterally into the Mottville Member (Meyer, 1985; Grasso, 1986). In the Skaneateles area, the Mottville is expressed largely as a 10 m-thick calcareous mudstone unit recording higher sedimentation rates under minimally oxic conditions. Both at and east of the Otisco Lake meridian, the Mottville dramatically thins and changes eastward to calcareous silty mudstone and siltstone beds yielding a diverse brachiopod and coral-rich fauna (Grasso, 1986). We believe that the Stafford central limestone ledge may link directly to the lower of two Mottville coral-rich silty limestone ledges at the Syracuse meridian. Clearly, the westernmost Mottville and Stafford members represent deeper water conditions than are indicated for the Syracuse-area Mottville.

The overwhelming balance of the Skaneateles Formation between the Stafford-Mottville interval and the Centerfield Member of the basal Ludlowville Formation is represented by the Levanna Shale Member. In the field trip area this 35-70 m thick unit is generally composed of dark gray fissile shale yielding a dysoxic, outer shelf fauna of small brachiopods, diminutive molluscs, occasional trilobites and flattened orthoconic cephalopods. However, our observations show that the Levanna is not monotonous, but subdivisable into traceable units, some of which are associated with significant erosional bounding surfaces (see below).

Both at and east of the Syracuse meridian the post-Mottville Skaneateles succession can be vertically subdivided into units each characterized by an upward (regressive) gradation from fissile shale into siltstone facies which is, in turn, bounded by an abrupt, transgressive change to shale (Cooper, 1930; Smith, 1935; Grasso, 1986). These divisions, including in respective ascending order: the Cole Hill, upper Delphi Station, "lower Pompey," "upper Pompey," (or Marietta) and Butternut-Chenango cycles, are collectively correlative to the Levanna Member with the exception of the Chenango Member which is correlative with the lower half of the Centerfield Member (Grasso, 1986; Gray, 1984, 1991). Westward correlation of regressive tongues and bounding surfaces of these cycles into the Levanna is the subject of ongoing STATEMAP work (Figs. 2, 3), but relevant new developments are reviewed below. The most important observations to date include: a) identification of the top-Cole Hill horizon as a condensed, shell-auloporid-rich bed or discontinuity westward of the Seneca Lake meridian; b) linkage of the top-Delphi Station cycle interval with a distinctive cluster of limestones and shell beds within the medial Levanna in the Genesee Valley-Batavia region (see below); c) linkage of the lower Pompey cycle cap to an erosion surface in the Genesee Valley-Buffalo region (see below); linkage of the upper Pompey cycle cap to a cluster of shell beds and concretionary layers that can be traced as far west as the Batavia meridian. Our observations show that most of the upper Levanna Member (corresponding to the Pompey and Butternut members in central New York) grades into black, fissile shale in Erie County and is, as yet, not subdivided into lithologic or cyclic units.

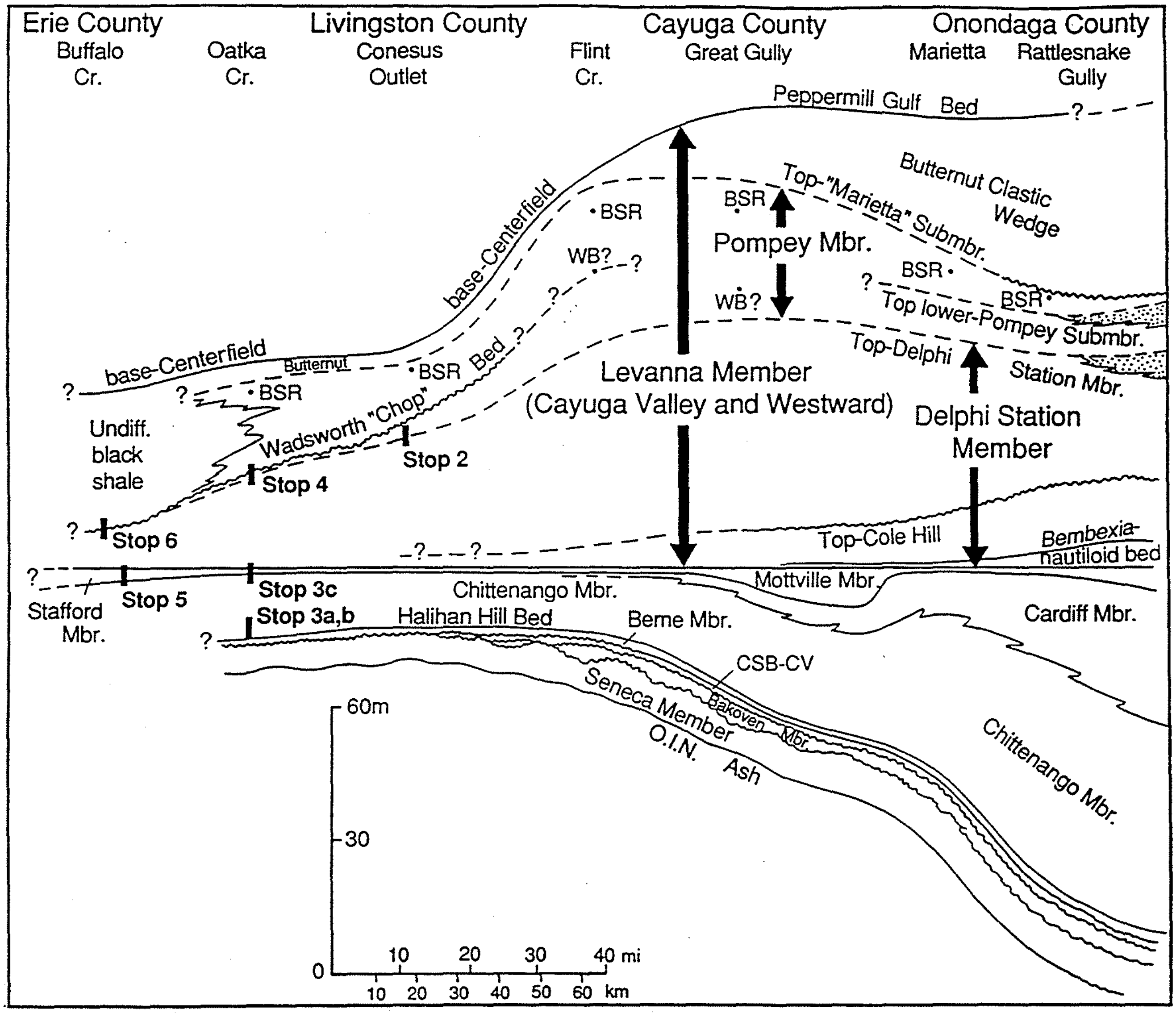

Figure 3. Regional stratigraphy of uppermost Onondaga Formation and lower part of Hamilton Group in western New York. Note that basal Hamilton divisions (Union Springs Formation, basal Oatka Creek Formation) are extremely thin compared to younger units. Dashed lines show tentative correlations of central New York Skaneateles divisions to key Levanna markers (see text).

DESCRIPTION AND DISCUSSION OF KEY UNITS AND CONTACTS

Seneca Member-Union Springs Formation unit relationships

In the study area the Seneca Member of the Onondaga Formation is underlain by the Onondaga Indian Nation K-bentonite, an isochron that has yielded a precise K-Ar age of 390. M.Y. (Fig. 4). The succeeding Seneca Limestone is moderately fossiliferous in the LeRoy-Stafford region, but grades eastward into sparsely fossiliferous lime mudstone facies in a more basinal setting centered in the Cayuga Valley (Ver Straeten et al., 1994). Immediately below the level of a higher ash bed ("Tioga restricted" K-bentonite) Onondaga carbonates give way to black shale and bituminous limestones of the Bakoven Member of the Union Springs Formation (Fig. 4). A minor disconformity marks the top of the Seneca Member at the Honeoye Falls Quarry (STOP 1) near Lima and nearly directly underlies the Tioga Restricted Ash. Just above the "Tioga restricted" ash, however, is a thin bone-styliolinid bed which is locally spectacular as in the Jamesville Quarry near Syracuse.

Key Union Springs Formation Units

Bakoven Member (STOP 1) – The Bakoven Member consists of interbedded sooty black shale and bituminous concretionary limestone beds and styliolinid concentrations. This unit is marked by bone beds and the "Tioga Restricted" (Tioga "13") K-bentonite both at and near the base. The Bakoven fauna is extremely depauperate, yielding *Eumetabolotoechia* (*"Leiorhynchus"*) *limitare*, very large *Panenka* bivalves, *Styliolina* and zonally important goniatites. The Bakoven thickness ranges from 0-4 m, but it is highly variable.

Chestnut Street Submember (STOP 1) – This unit is a thin (15-30 cm-thick) partly truncated gray limestone bed rich in pelmatozoan debris, brachiopods, trilobites, and small corals. Distinctive fossils include ambocoeliid and atrypoid brachiopods, common proetid trilobite exuviae and the microcrinoid *Haplocrinites*. The base of this unit marks a discontinuity. The Cherry Valley Limestone variably truncates the Chestnut Street Bed across western New York (Fig. 4).

At the Rochester meridian, the Bakoven is nearly absent due to beveling beneath the Cherry Valley Limestone (Figs. 3-5). In a new drill core, obtained from the site of the new American Rock Salt Mine at Hampton Corners south of Geneseo, 0.7-1.3 m of Bakoven Member is observed below the Cherry Valley Member. Similarly, 2.6 m of Bakoven Member was observed in the Livonia Salt Shaft as suggested by lithologic descriptions of Luther and Clarke (1893) and Clarke (1901).

To the west of the Honeoye Falls quarry and the new American Rock Salt core site, no Bakoven beds have been observed to date. In two older AKZO cores obtained from the area of the now flooded AKZO mine at Greigsville, the Berne Member of the Oatka Creek Formation directly overlies a conspicuous pyrite-coated discontinuity surface developed on the Seneca Member (Baird and Brett, 1991: Fig. 6, p.244). Similarly, the

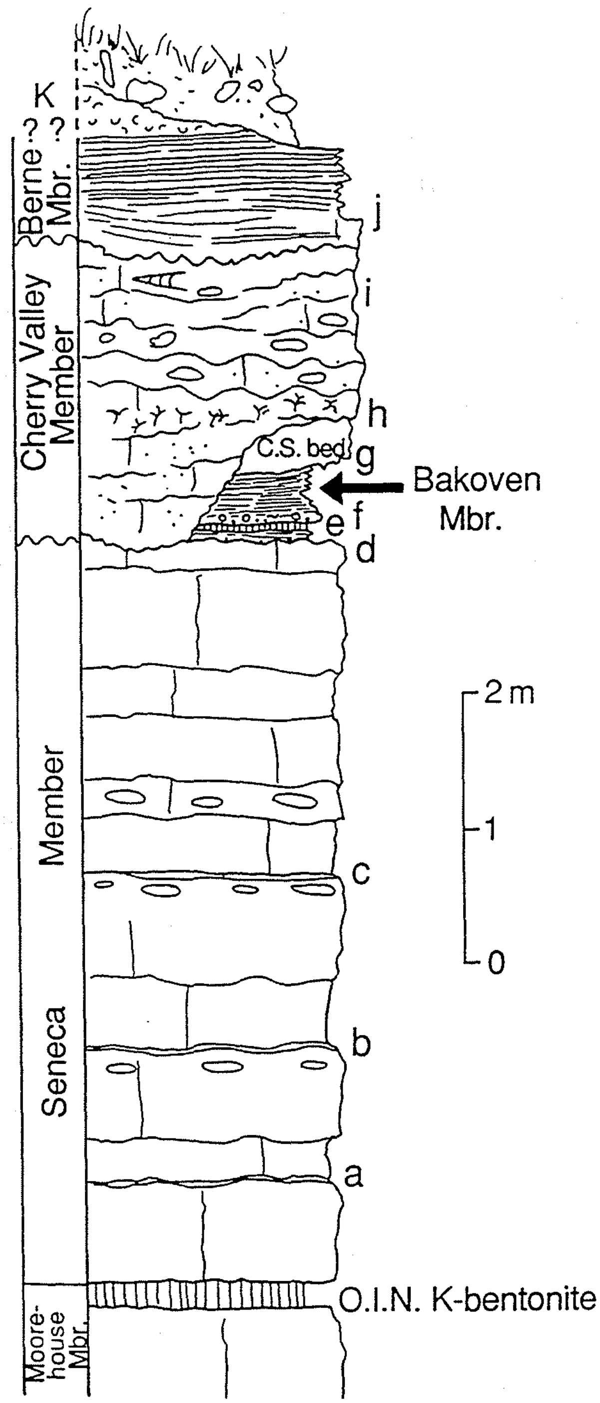

Figure 4. Uppermost Onondaga Formation-through-lower part of Oatka Creek Formation succession exposed in General Crushed Stone Quarry near Honeoye Falls (STOP 1). Lettered units include: a-c, thin K-bentonite beds in Seneca Member; d, diastemic erosion surface at top of Seneca Member; e, Tioga "F" K-bentonite bed; f, bone bed in lower part of Bakoven Member; g, Chestnut Street Bed; h, channeled disconformity surface at base of Cherry Valley Member; I, cephalopod-bearing interval in upper part of Cherry Valley; j, top-Cherry Valley corrosional discontinuity overlain by Berne Member.

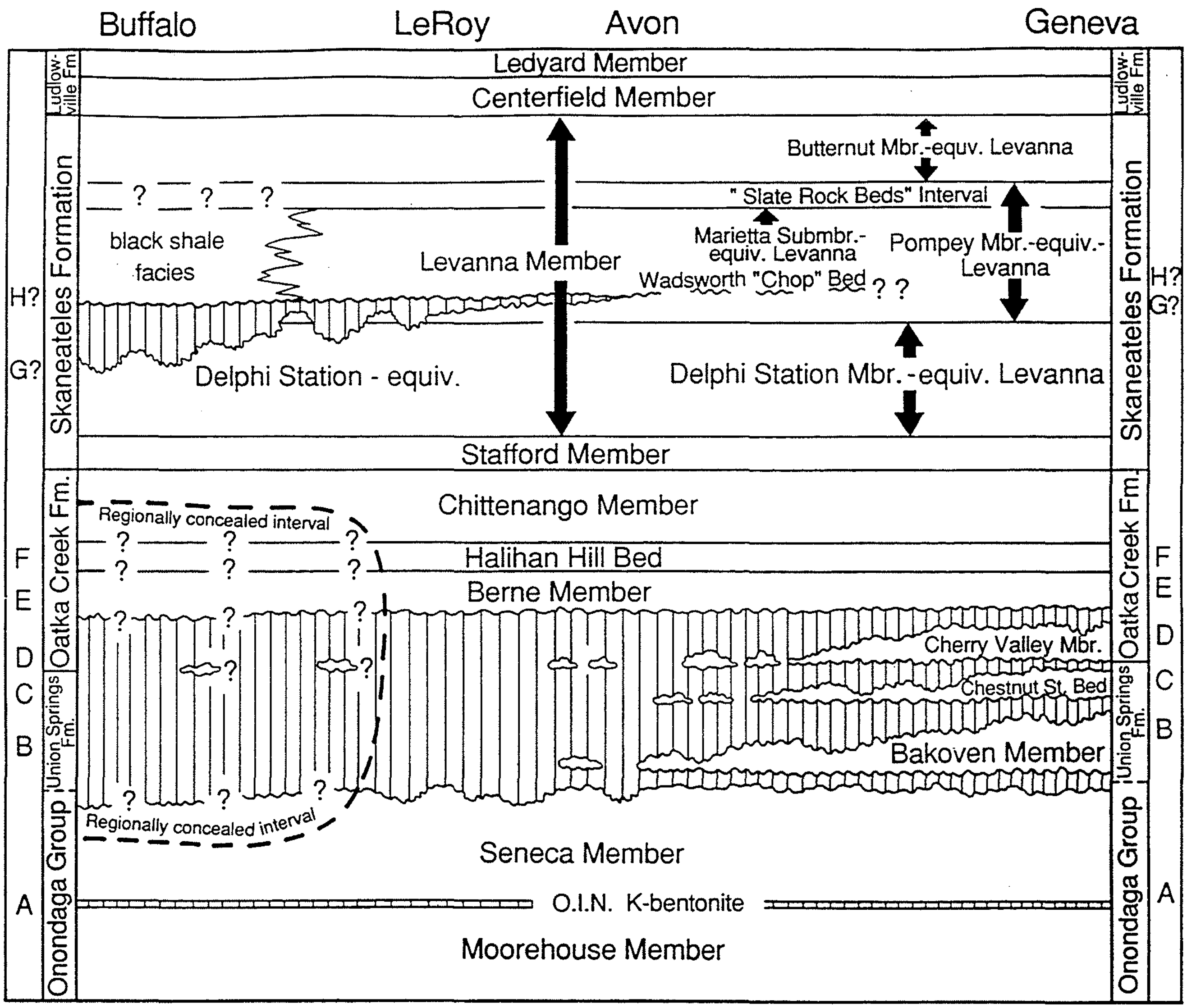

Figure 5. Time-rock relationships of sedimentary divisions in the uppermost Onondaga Formation and in the lower half of the Hamilton Group across western New York. Note development of composite disconformity below Berne Member west of the Genesee Valley and development of medial Levanna disconformity mainly west of the LeRoy meridian. Heavy dashed line encloses part of diagram where strata are concealed and reconstruction is conjectural. Lettered units include: A, Onondaga Indian Nation K-bentonite; B, *Cabrieroceras_plebieforme* zone; C, *Haplocrinites* level; D, *Agoniatites vanuxemi* level; E, styliolinid-dacryoconariid-bearing black shale (Berne Member); F, lowest level of Hamilton macrofauna; G?-H?, possible *ensensis*-lower *varcus* zonal conodont boundary.

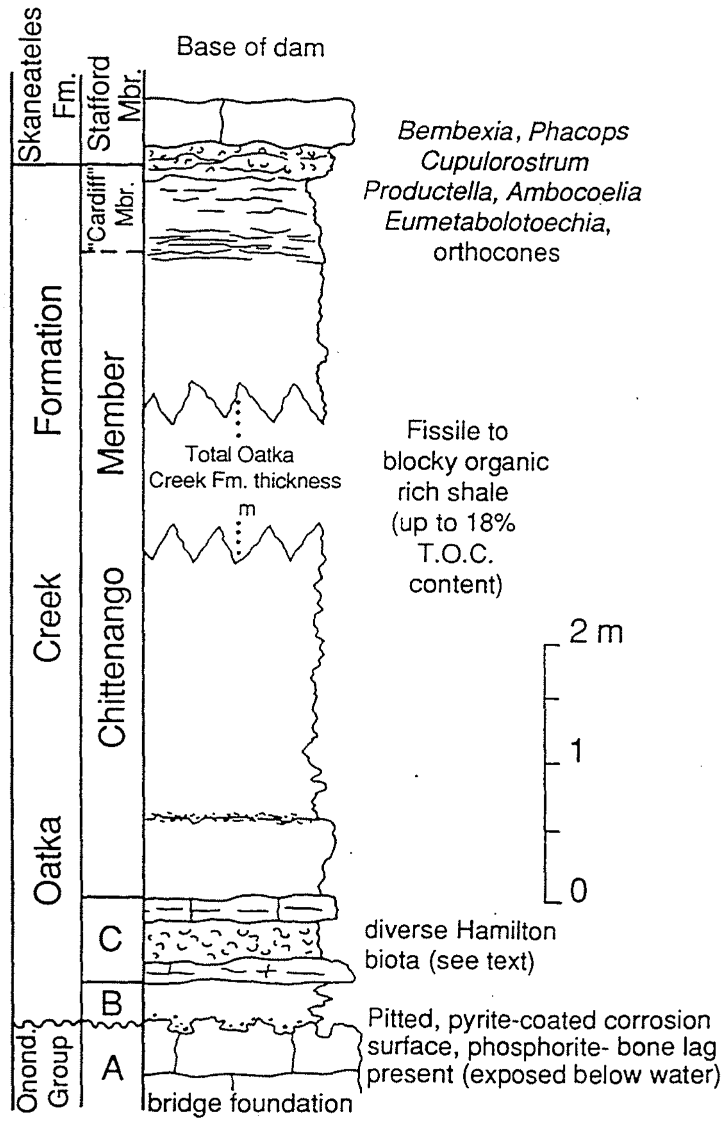

Figure 6. Section flooring Oatka Creek in town of LeRoy, Genesee County (STOP 3a-c). Key units include: A, top of Seneca Member of Onondaga Formation; B, black shale representing condensed Berne Member section; C, richly fossiliferous gray mudstone deposits of Halihan Hill Member.

Berne rests on an irregular pitted, pyrite mineralized top-Seneca contact along Oatka Creek (STOP 3a) in LeRoy. This discontinuity is also visible in the Honeoye Falls Quarry (STOP 1) but it is of smaller magnitude in that area given that the subjacent Bakoven and Cherry Valley members are present there (Figs. 4, 5). In essence, no less than four discontinuities: the base-Bakoven diastem, a lower Bakoven bone-bed contact, a major base-Cherry Valley contact, and the base-Berne discontinuity are collectively cutting out portions of the overall section in the vicinity of Lima and the new American Rock Salt mine. To the northwest, sub-Berne corrosional overstep is such that a composite disconformity is developed and the entire Union Springs Formation is absent (Figs. 3, 5, and 6). At Oatka Creek (STOP 3a), the Seneca Member-Berne Member contact is below water and can be accessed only with difficulty.

Key Oatka Creek Formation Units

Cherry Valley Member (STOP 1) – This is the well known "Agoniatites Limestone" of early workers. In western New York the Cherry Valley is a thin (0.2.0 m-thick) brown, petroliferous and nodular limestone composed largely of *Styliolina fissurella* tests. The Cherry Valley limestone is particularly distinctive for abundant auloporid thickets and cephalopod conchs. *Agoniatites vanuxemi* is locally abundant; this goniatite occurs in association with orthocones in vast cephalopod pavements within the upper part of the unit (see Cottrell, 1972; Baird and Brett, 1986; Griffing and Ver Straeten, 1991; Ver Straeten et al., 1994). The Cherry Valley Member is a rare example of a "cephalopod limestone" (cephalopodenkalk) in the New York Devonian section. Such units are believed to reflect conditions of sediment starvation in offshore and/or deeper water settings. The Cherry Valley represents a transgressive systems tract associated with sea level-rise following deposition of the Stony Hollow-Chestnut Street Bed Interval (Ver Straeten et al., 1994). We will see the Cherry Valley Member at its westernmost accessible locality at STOP 1 (Fig. 4). West of the Genesee Valley, both it and the underlying Union Spring Formation divisions are missing due to erosion in most areas (Figs. 5, 6).

Berne Member (accessible at STOP 1) – This is a 30 cm-thick interval of black shale, rich in styliolinids and dacryoconariids. As noted above, it is the thin condensed equivalent of a much thicker shale succession in eastern New York. This unit, marking the zonal base of the Givetian Stage overlies a regional, corrosional discontinuity. At Oatka Creek (STOP 3a) it is erosionally juxtaposed onto the Seneca Member (Fig. 6).

Halihan Hill Bed (STOP 3a) – As noted above, the temporal debut of the Hamilton Evolutionary-Ecological Biota appears to be very sudden and dramatic. Overlying a 40 cm-thick condensed Berne section on Oatka Creek (STOP 3a) is a profusely fossiliferous interval of shell-rich, soft, gray mudstone which is exposed in the floor of the creek (Fig. 6). This 30 cm-thick unit yields small rugose corals, *Mediospirifer, Tropidoleptus, Meristella, Phacops,* encrusting and fenestrate bryozoans as well as many other taxa. Near Schoharie, this bed yielded the distinctive button coral *Microcyclus*. Larger corals, including *Heterophrentis, Heliophyllum*, and *Cystiphylloides* are observed in localities near Kingston. The Halihan Hill Bed, is widespread and regressive relative to synjacent black shale facies, and is everywhere thin. Unlike similar recurrent facies higher within the Hamilton Group, the Halihan Hill Bed does not appear to thicken eastward (and shoreward). This unit displays the shallowest water facies encountered in the Oatka Creek and Skaneateles formations in western New York.

Chittenango Member (STOP 3a-c) – Above the Halihan Hill Bed is a 10 m-thick interval of massive, well jointed, hard black shale that records maximum development of Devonian anoxia in this region (Fig. 6). This shale, yielding up to 18% T.O.C., is uniformly thin across the study area attesting to early highstand conditions with very low siliciclastic sediment supply. Because this unit is highly radioactive, it is a major marker in geophysical logs. Below the Stafford Member is a thin interval of calcareous shale that is less organic-rich than that of the typical underlying Chittenango. *Eumetabolotoechia* ("*Leiorhynchus*") *limitare* and orthocones attest to minimally dysoxic bottom conditions. Although thin and poorly defined on Oatka Creek, this interval does grade eastward into a thicker, gray shale division identified as the Cardiff Member in central New York (Figs. 2, 3).

Oatka Creek Formation Unit Relationships

In the present field trip area few lateral lithologic and thickness changes are noted within the Oatka Creek Formation interval. The stratigraphy is rather of a "layer cake" nature and all component units apparently accumulated in a sediment-starved setting (Figs. 2, 3). Unfortunately the lower part of the Oatka Creek Formation is concealed west of LeRoy and the nature of the Cherry Valley Member-Halihan Hill interval in Erie County is poorly known (see below).

Regionally, the Cherry Valley Limestone extends from the Hudson Valley, where it overlies the Stony Hollow Member (Griffing and Ver Straeten, 1991; Ver Straeten et al., 1994) westward to the Genesee Valley where it is unconformably overlain by black shale deposits of the Berne Member (Figs. 2, 3). Beginning approximately at the Genesee Valley meridian, the Cherry Valley is regionally beveled and is clearly absent, both in drill cores from the old AKZO mine near Griegsville and at LeRoy (STOP 3a). As noted above, the sub-Berne corrosional disconformity is responsible for this erosion (Figs. 5, 6). Clarke (1901) claimed to have found the "*Agoniatites* limestone" (Cherry Valley Member) on Little Conesus Creek south of Avon, New York. Recent examination of Little Conesus Creek suggests that Clarkes' "*Agoniatites* limestone," which was supposed to be present above the Erie Railroad overpass, is actually the Stafford Member. Ironically, the sub-Berne disconformity was found further downstream on this creek. However, the poor quality of the exposure preclude positive identification of the sub-Berne carbonate as Seneca Member or Cherry Valley Member. Clarke (1901) indicated that "*Agoniatites*" was observed at the base of the "Marcellus Shale" section in a borehole section at Stony Point on Lake Erie. Similarly, carbonate yielding *Agoniatites* has been reported from the vicinity of Lime Rock east of LeRoy. In essence, outliers of uneroded Cherry Valley may underlie western New York in many areas (Fig. 5).

In the Honeoye Falls Quarry, the Cherry Valley displays a channeled lower surface and overlies variable thicknesses of Bakoven Shale and even a small remnant of Chestnut Street submember; (Fig. 4). In the Livonia salt shaft, south of the Honeoye Falls Quarry, 2.6 m of Bakoven shale and approximately 1.3 m of Cherry Valley? limestone were reported (Clarke, 1901). Similarly, 2 m of Bakoven is reported in cores taken from the new American Rock Salt mine site at Hampton Corners south of Geneseo (Brett and Ver Straeten, pers. comm.). As noted above, the old AKZO cores from Griegsville, 12 km to the northwest of the new mine and 5 km southwest of Little Conesus Creak, show complete removal of Bakoven, Chestnut Street and Cherry Valley deposits by sub-Berne erosion.

With the exception of the Halihan Hill Bed, the paleoenvironment of the post-Cherry Valley-Oatka Creek succession was that of a deep water, anoxic basin (Baird and Brett, 1986, 1991); two discrete highstand events (Berne, Chittenango Members), however, are separated by the problematic, major regional lowstand/transgressive facies interval of the Halihan Hill Bed. The widespread nature of the Halihan Hill Bed strongly indicates that the regression event recorded in it was of an eustatic origin.

Key Skaneateles Formation Units (see STOPS 2-6)

Stafford Member (STOPS 3c, 5) – In the Genesee Valley-Oatka Creek area, the Stafford member is a thin, 1.5-2.0 m-thick interval centered on a resistant limestone bed which is 0.25-0.6 m in thickness (Fig. 6). Beneath the limestone ledge, dark gray calcareous shale beds of the basal Stafford yield numerous small brachiopods, diminutive gastropods and bivalves, and flattened cephalopods. Brachiopods include *Crurispira nana, Truncalosia truncata*, and *Eumetabolotoechia ("Leiorhynchus") limitare*. Many of the flattened orthocones display current-aligned colonies of the problematic organism *Reptaria stolonifera* (Baird et al., 1989); these encrusters appear to have encrusted the shells of live orthocone hosts, responding rheotrophically to the host's motion.

The Stafford Limestone ledge, conformably overlying the calcareous shale interval, yields a slightly richer, but still modest faunal assemblage. Notable are the occurrences of numerous gastropods and orthoconic cephalopods that are preserved three dimensionally as spar filled natural casts or as coarse black calcite replacements of aragonite. The limestone is gray brown in color and is petroliferous. Generally the skeletal fabric is that of a wackestone except where fossils are locally concentrated in burrow fillings. Key taxa include the brachiopods *Longispina* and *Cupulorostrum sappho*, sparse small rugosans, the gastropod *Bembexia sulcomarginata*, nuculoid bivalves and orthocones. The fauna reflects minimally oxic conditions in an outer shelf setting. The upper Stafford transition into the Levanna Member is not exposed on Oatka Creek, but where seen, consists of calcareous, dark gray, petroliferous shale with a sparse dysoxic fauna.

In Erie County (STOP 5) the Stafford is thicker and more differentiated lithologically (Fig. 7). In Lancaster (Plumbottom Creek and Cayuga Creek (STOP 5)), it is 2.5 m-thick starting with an 19 cm-thick basal limestone ledge rich in *Ambocoelia, Emanuella*, and

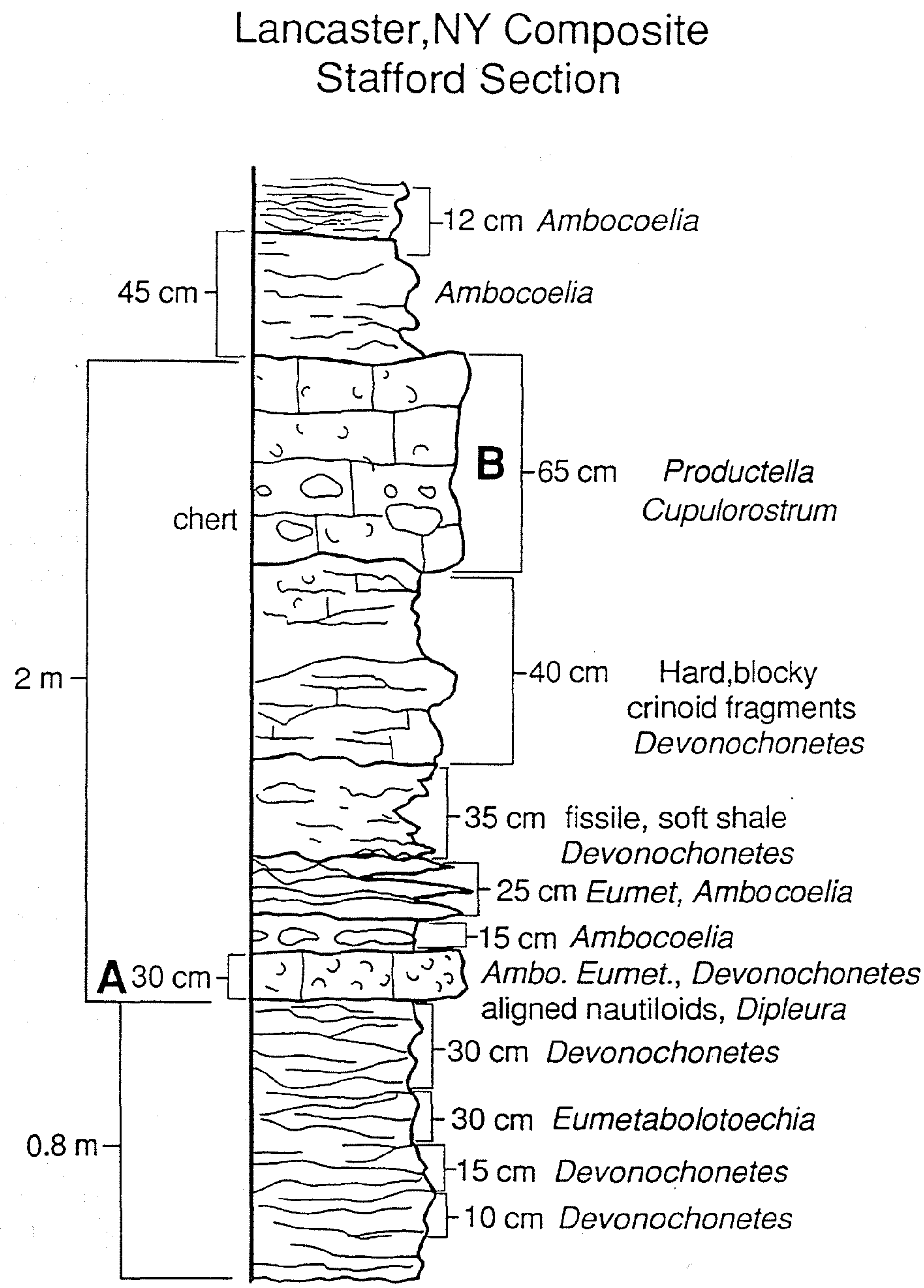

Figure 7. Composite Stafford Member section based on sections at Como Park, Lancaster, New York (STOP 5) and on Plum Bottom Creek, also in Lancaster. Unit A is *Ambocoelia* and *Devonochonetes*-rich limestone bed which is probably correlative with the basal Mottville "sub-A" interval in central New York (see text). Unit B is chert-rich limestone bed that probably correlates to the Mottville "B" ledge (Case Hill coral bed) of central New York sections (see text).

orthocones as well as an unusual occurrence of the trilobite *Dipleura*. This shell-rich unit ("Sub-A Bed") is succeeded by a 18 cm-thick calcareous shale unit yielding *Emanuella*, large *Aulocystis* and abundant *Phacops*. Above this interval is an 18 cm-thick hard limestone rich in crinoidal debris at the base and a sparse molluscan fauna above. This unit may correlate to the "A Bed" of the Mottville in central New York localities. Above the second limestone bed is 0.7 m of impure, lenticular to nodular concretionary limestone yielding a sparse fauna. The top of the Erie County Stafford, visible on Plum bottom and Buffalo Creeks, is increasingly characterized by buff to brown weathering (dolomitic?) impure cherty nodules (Fig. 7). Above the concretionary zone is a 0.3-0.5 m-thick unit ("B Bed") consisting of hard limestone with widely scattered chert nodules. Fossils are sparse in this unit, but include small favositid and auloporid corals, as well as the brachiopods *Meristella, Camarotoechia*, and *Productella*. Still further west, on Buffalo Creek, the Stafford thickens to 3 m overall and becomes distinctly more cherty in the upper ("B Bed") part.

Regionally, the Stafford is thin and stratigraphically condensed in the Waterloo-Stafford region but thickens both to the east and west of this area (Fig. 3). As noted above, it thickens westward to 3 m in Erie County and is marked by an ambocoeliid-rich limestone ("Sub-A Bed") near its base and a somewhat thicker limey zone with chert nodules ("B Bed") near its top. However, the Stafford Member thickens eastward from 0.5 m south of Waterloo to 2.7 m at Great Gully east of Cayuga Lake and 3 m near Half Acre southwest of Auburn. In this area, a 20-25 cm-thick "Sub-A" bed rich in ambocoeliids is succeeded by 2.3 m of calcareous, slightly silty mudstone and nodular limestone layers with a sparse fauna. The lower part of this interval displays impure concretionary, lenticular limey beds whereas the top third of the interval displays dolomitic? and variably siliceous nodules. The top "B Bed" ledge is a 30-35 cm-thick layer of hard impure, unfossiliferous limestone rich in siliceous and dolomitic nodules. Meyer (1985) noted the striking physical similarity of the Great Gulf and Lancaster sections despite the notable thinness of intervening sections. The present authors, noting the similarity of the Lancaster and Half Acre (Auburn) sections, conclude that the "sub-A", "A", and "B" units mark eustatic signals that may be widespread.

Eastward from the Great Gulf and Half Acre sections, we observe continued thickening of the overall section to maximum values of 8 m-thickness near Skaneateles (Fig. 3). Here, the Stafford has transformed into a mud-dominated unit represented by the type-Mottville section (Meyer, 1985; Grasso, 1986). Recent work by the present authors, shows that the thick Skaneateles Mottville sections are clearly subdivisable into units that can be correlated to the east and west of there. This work is still in progress.

Levanna Member (STOPS 2, 4, 6)

<u>Overview</u> – As noted above, this division is stratigraphically thick and poorly exposed. Parts of it cannot be easily measured since it is often exposed on floors of swampy, low gradient creeks. However, we believe that the lower half of the Levanna corresponds to the undifferentiated basinward equivalents of the siltstone-capped Delphi Station Member in central New York (see Grasso, 1986; Linsley, 1991: see Figs. 3, 5). We

presently recognize the top Cole Hill horizon (lower Delphi Station Member) west to the Phelps meridian and tentatively to the Genesee Valley as a thin, small brachiopod, small mollusc and auloporid-bearing layer approximately 4 m above the top of the Stafford. However, much of the lower Levanna succession both below and above the Cole Hill position is sparsely fossiliferous dark gray to nearly black shale. The succession becomes progressively more calcareous and fossil-rich as one proceeds upward through the lower half of the Levanna. This regressive trend culminates in the Papermill and Pole Bridge limestone beds which are conspicuous falls-capping units in the Genesee Valley. These apparently link eastward respectively to two siltstone beds at the top of the Delphi Station Member in the Syracuse-Cazenovia area (Figs 3, 5).

Above the Pole Bridge marker is a return to shale-dominated facies which is, in turn, capped by two separate sets of concretionary limestone layers (Wadsworth beds and Slate Rock beds) yielding small brachiopods and some auloporid corals. The lower pair of limestones (Wadsworth beds) are believed to link to siltstones capping Cooper's (1930) Pompey Member, and the upper bundle of shell-rich-beds (Slate Rock beds) marks the top of a second siltstone-capped interval in central New York that we provisionally named the "Marietta submember" (Fig. 3).

The topmost 3-4 m of the Levanna below the Centerfield Member consists of organic-rich, fissile black shale. This is believed to be correlative with the Butternut Member in central New York (Figs. 3, 5).

Key Levanna Markers

Molluscan debris layer near base of Levanna – On Flint Creek near Phelps 4 m above the base of the Levanna we observe a 12 cm-thick layer of auloporid-rich mudstone yielding numerous nuculoid bivalves and gastropods. We believe that this unit may be the westernmost observed expression of the Cole Hill Cycle regression event that produced a prominent fossil-rich sandstone unit in central New York (Linsley, 1991), Fig. 3).

Papermill Limestone Bed – 0.5-8 m below the top of the Delphi-Station-equivalent part of the Levanna in the Geneva-LeRoy area we observe a resistant, 0.6-0.85 m-thick limestone bed that holds up waterfalls on Conesus and Little Conesus Creeks near Avon (see STOPS 2, 4). We herein informally designate this unit the Papermill Limestone Bed for an excellent exposure on Conesus Creek (STOP 2) where it caps a falls below Papermill Road southeast of Ashantee, Livingston County (Genesee 7.5' Quad.). This unit has been mistaken for Stafford by early workers. It yields a sparse fauna of auloporids, small bivalves and gastropods. It is really the most prominent ledge of several impure limestone layers in the lower medial part of the Levanna Member (Figs. 8, 9). West of Oatka Creek (STOP 4) this unit has not been observed to date; it may grade westward into less resistant shalier carbonate or it may be erosionally overstepped by the "Union Road disconformity" (Fig. 9). East of the Avon area, the Papermill gradually becomes less resistant, changing to several stacked concretionary limestone beds on Flint Creek at Orleans. It is last seen on a small creek near the Rose Hill mansion east of

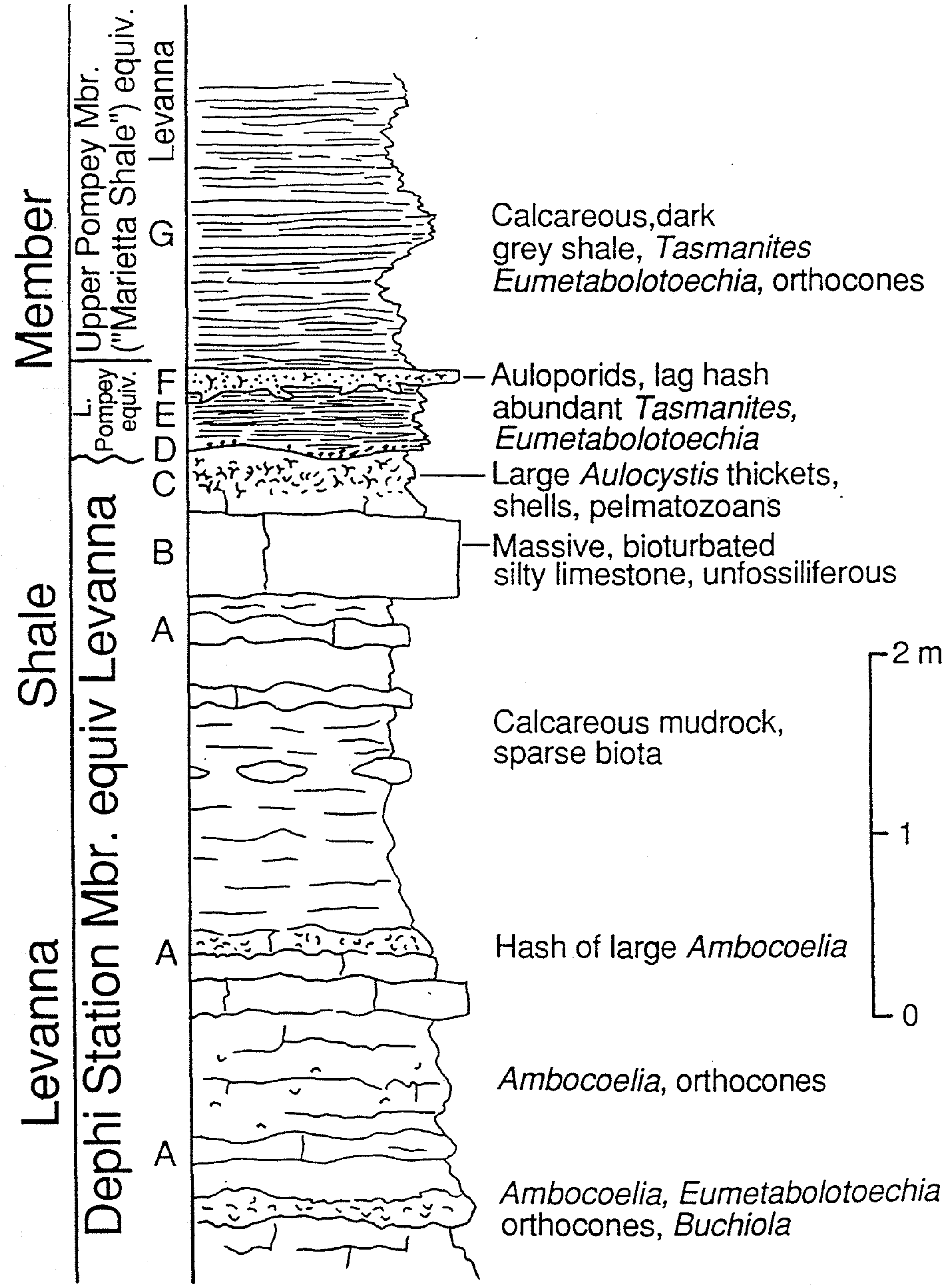

Figure 8. Section flooring Oatka Creek downstream from Covell Road overpass southeast of Roanoke, Genesee County (STOP 4). Lettered units include: A, concretionary impure limestone beds with minor shell beds; B, Papermill Limestone Bed; C, auloporid thicket interval of Roanoke Bed; D, black shale-roofed discontinuity marked by lag of reworked pyrite and fish bones; E, *Tasmanites*-rich "highstand" black shale unit; F, Wadsworth Bed characterized by comminuted shell hash, conodonts and fish bones that fill *Thallasinoides* burrow prods into underlying shale; G, dark, fissile shale yielding *Devonochonetes* and flattened rhynchonellids.

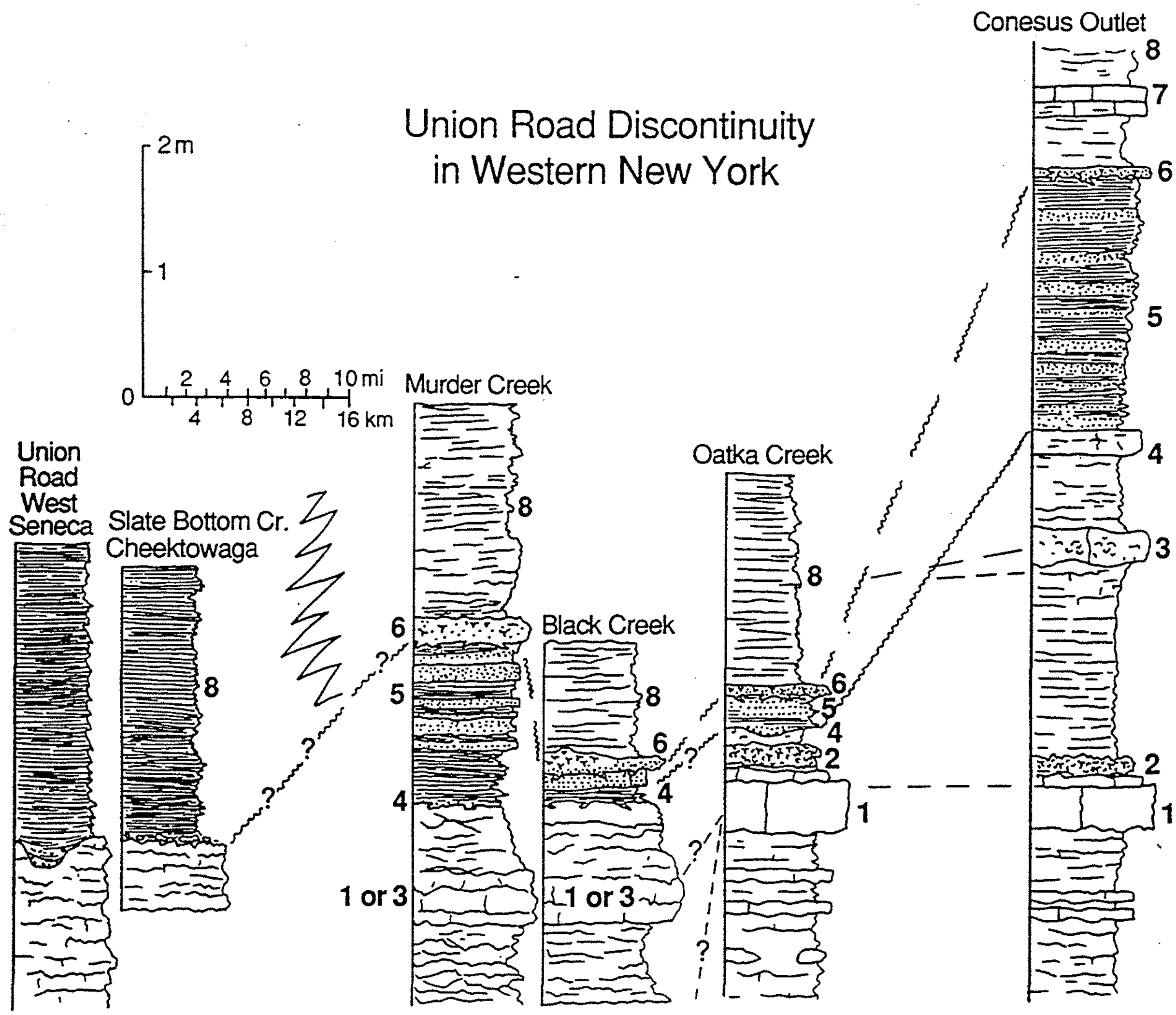

Figure 9. Tentative correlation scheme for key marker beds in the medial Levanna Member in western New York. It shows provisional westward correlation of inferred top-"Delphi Station"-base "Pompay" contact within the Levanna Member in the Genesee Valley to the Union Road disconformity in Erie County (see text). Numbered units include: 1, Papermill Bed; 2, Roanoke Bed; 3, lower Pole Bridge Bed; 4, upper Pole Bridge Bed; 5, dark fissile shale unit with abundant *Tasmanites* and flattened rhynchonellids; 6, lower (main) Wadsworth Bed; 7, upper (minor) Wadsworth Bed; 8, dark gray, fissile shale (correlative? With "Marietta Shale" in central New York).

Seneca Lake where it is represented by a 1.5 m-thick bundle of thin, barren ribbon limestones in an otherwise shaley succession. East of the Rose Hill locality in the Cayuga Valley this unit becomes shyly and nonresistant. Further east, we believe that it corresponds to the lower of two prominent siltstone beds that mark the top of the Delphi Station Member in the Syracuse area.

Roanoke Bed – Capping the Papermill Bed in Genesee Valley localities and also along Oatka Creek (STOP 4) is a 9-20 cm-thick layer that is profusely fossiliferous (Figs. 8, 9). We herein name this bed the Roanoke Bed for its occurrence on Oatka Creek downstream from the overpass southeast of the hamlet of Roanoke, Genesee County (Stafford 7.5' Quad: STOP 4), where it is best developed. At this locality it reaches peak development. The Roanoke Bed is characterized by colonial thicket growths of a large species of *Aulocystis* in association with brachiopods, trilobites and pelmatozoans. Occasional *Pseudoatrypa* and *Rhipidomella* occur in this layer, as does *Phacops rana* and the crinoid *Arthracantha*. Fossils are densely concentrated both in and around the thickets, but are more scattered in a thin overlying interval of soft, gray fossiliferous shale. At Conesus and Little Conesus Creeks near Avon this unit is thinner, but still rich in fossils (Figs. 8, 9). On Flint Creek at Orleans, the Papermill Bed is capped by a thin fossil debris layer yielding *Ambocaelia* and small auloporid debris that is the apparent expression of this bed in the vicinity of Phelps.

Pole Bridge Beds – We herein informally designate two 20 cm-thick shell-rich limestone layers, occurring respectively 1.4 and 2.3 m above the Roanoke Bed in the Genesee Valley region as the Pole Bridge bed for exposures on Little Conesus Creek below Pole Bridge Road near Avon, Livingston County (Rush 7.5' Quad.). At this section and on the adjacent Conesus Creek the lower Pole Bridge Limestone Bed is characterized by abundant *Ambocoelia umbonata* and rare specimens of the small rugose coral *Stereolasma*. The upper Pole Bridge Bed, occurring 0.75 m above the lower bed is less resistant and internally more complex. In addition to *Ambocoelia*, and *Devonochonetes* it contains abundant flattened rhynchonellids and profuse concentrations of *Tasmanites*, such that the beds appear granular and "oolitic". On Flint Creek at Orleans and near the Rose Hill mansion east of Seneca Lake, the Pole Bridge Beds are expressed as dense *Ambocoelia* concentrations in shale. East of Rose Hill these layers apparently persist into Onondaga County where they occur as mollusc-dominated shell beds above prominent siltstone beds at the top of the Delphi Station Member. West of the Genesee Valley these beds have not been found (Fig. 9).

Tasmanites–rich black shale unit – Commencing above the second Pole Bridge Bed on Conesus Creek is a change to black fissile to platy shale abounding in the algal phycoma organ *Tasmanites* and flattened-fragmented rhynchonellids. Beds at the base of this 3.0 m-thick interval display bedding planes so rich in *Tasmanites* as to appear granular; cysts are particularly concentrated in *Planolites* burrows. East of the Genesee Valley the *Tasmanites*-rich zone has not been identified with any certainty. However, it appears to be present on Oatka, Black, and Murder creeks in Genesee County (Fig. 9). On Oatka Creek (STOP 4), the Roanoke Bed is unconformably overlain by a 33 cm-thick, fissile black shale unit yielding abundant flattened rhynchonellids and *Tasmanites* (Fig. 8). This discontinuity is marked by a thin discontinuous lag deposit of reworked pyrite similar to other black shale-roofed detrital pyrite beds (Leicester Pyrite, Skinner Run Pyrite Bed) described by Baird and Brett (1991). Conodonts from this lag may belong to either the uppermost *ensensis* zone or the lowest part of the *varcus* zone as this zonal boundary may be near this level. At Conesus, Black and Murder Creeks, however, the base of this shale unit appears to be non-erosional and conformable.

Wadsworth Bed – On Conesus Creek, the *Tasmanites*-rich shale unit is abruptly overlain by a 8-10 cm-thick bed abounding in *Ambocoelia,* crinoid debris and auloporid coral thickets. We herein designate this unit the Wadsworth Bed owing to its proximity to the Wadsworth Boy Scout Camp along Conesus Creek. This bed occurs only a short distance south of (upstream from) the Paper Mill Road overpass and the Papermill bed type section on Conesus Creek south of Avon (Geneseo 7.5' Quad.). In addition to auloporids and small brachiopods, this bed contains abundant conodonts and occasional fish bone debris indicating that this layer is, at least, partly erosional in origin.

We believe that this bed is present in several sections to the west and can be seen as far west as Erie County (Figs. 8-10). At all Genesee County sections (Oatka Creek, Black Creek, Murder Creek) it is lithologically similar to the type section occurrence and it has yielded fish bones and conodonts. Moreover, the Wadsworth Bed overlies variable thicknesses of black, fissile, *Tasmanites*-rich shale suggesting differential erosion of underlying beds. On Oatka Creek (STOP 4), it occurs only 33 cm above the unconformable base of the *Tasmanites*-rich black shale (Fig. 8). In Erie County, the top of the Delphi-Station-equivalent part of the Levanna is marked by a conspicuous disconformity (see below). We believe that the Wadsworth Bed may correlate to this discontinuity surface (Fig. 9). To the east, the Wadsworth Bed may connect to shell beds at the top of the Pompey Member in central New York but this correlation is, as yet, unproven.

Slate Rock Beds – Below Slate Rock Falls on Wilson Creek west of Seneca Lake (Ontario County, 7.5' Quad.) is an occurrence of a prominent tabular shell-rich limestone layer 3 m below the top of the Levanna and two to three associated concretionary layers in the underlying 2.5 m of section. The name Slate Rock beds is proposed to denote this widespread bundle of shell beds and concretionary layers which can be mapped within the upper Levanna from the Batavia meridian eastward into central New York. It marks the top of a medium to dark gray shale succession above the Wadsworth Bed and it conformably floors a fissile black shale unit (Butternut Member-equivalent) in all observed sections (Figs. 3, 5).

On Wilson Creek and at other sections where this unit occurs, there are usually two to three thin beds rich in *Devonochonetes scitulus, Ambocoelia umbonata, mucroclipeus,* and *Mucrospirifer mucronotus* that occur within a 2.5 m interval. Other fossils in these beds include auloporid corals and occasional *Stereolasma,* nuculoid bivalves, numerous *Phacops* exuviae, and orthoconic cephalopods. These organisms suggest upper dysoxic to minimally oxic conditions over a broad area. This fauna improves both in diversity and preservation as these beds are traced eastward into the Skaneateles-Tully Valley

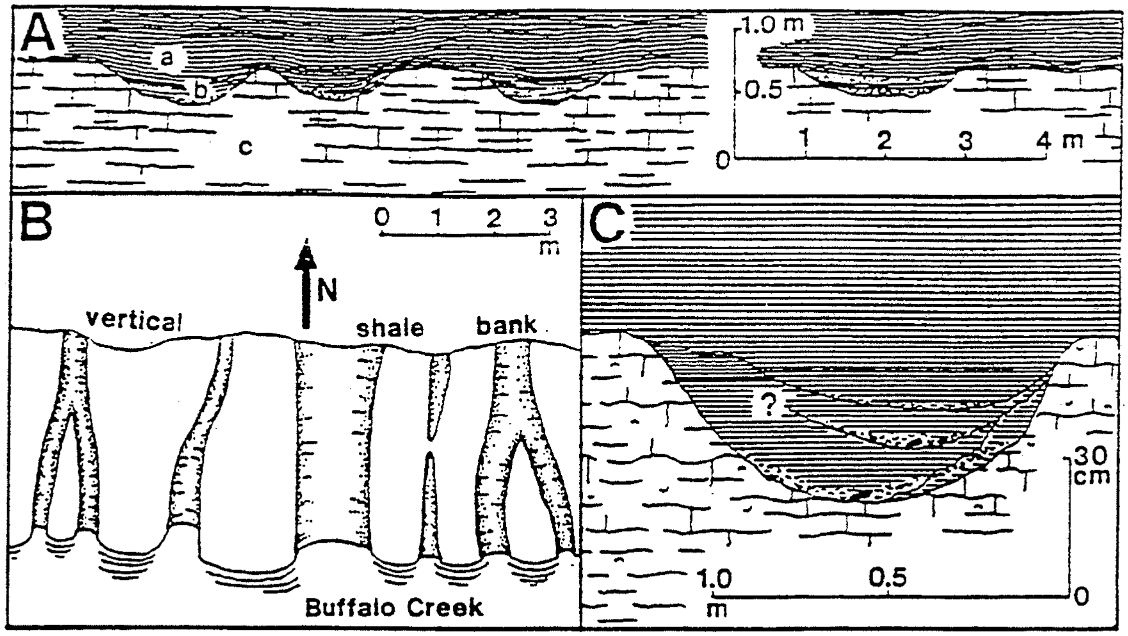

Figure 10. Submarine discontinuity within Levanna Shale Member on Buffalo Creek at Union Road (see STOP 6). A) along-bank profile of a series of erosional runnels (troughs) into calcareous mudstone that are filled with brownish-black shale of upper unit; B) vertical ("map") view of channels on exposed creek bed bordering shale bank. Note southward bifurcation of some channels suggestive of southward current-flow; C) complex history of episodic scouring and filling of mud within channels. Sharp scoured contacts with associated lag debris of fish bones and shells grade laterally to extinction (continuity) over very short distances. Lettered units include: a) black, laminated shale with flattened rhynchoneilids, *Styliolina*, and palynomorphs; b) brown-black shale filling in troughs with associated scoured contacts and brachiopod-trilobite fish bone lag debris; c) calcareous gray to dark gray blocky to chippy mudstone with *Ambocoelia, Devonochonetes,* and *Phacops rana.* From Brett and Baird (1990), Baird and Brett (1991).

region. In that area they cap a sedimentary interval that is distinct from the underlying Pompey Member and the overlying Butternut Member (Fig. 3). This unit, tentatively designated the "Marietta Member", is a subject of ongoing study.

West of the "East Bethany" (Francis Road) Centerfield Member locality in Genesee County, the Slate Rock beds interval is nowhere exposed. It is apparently hidden in the short covered interval on Buffalo Creek between Transit Road (US 20) and the Centerfield Member exposure upstream at Blossom.

Butternut Member–equivalent Levanna – West of Cayuga Lake the uppermost part of the Levanna Member is represented by a 3-5 m interval of hard, black, fissile shale that is characteristically jointed and characterized by flattened rhynchonellids and tasmanitids at many levels. This unit, separating the Slate Rock beds interval from the overlying Centerfield Member, is the thin lateral equivalent of the much thicker Butternut Member in central New York. Between Cayuga Lake and the Skaneateles Valley this part of the Levanna thickens from approximately 5 m to 35 m and, as formal Butternut Member, thickens further eastward to approximately 58 m in Madison County (Linsley, 1991, Fig. 3). Though notably thinner than the typical Butternut Member, this top-Levanna division is easily identified as Butternut as far west as the Francis Road Centerfield locality south of Batavia. Although not formally advanced in the present publication as Butternut Member, as distinct from Levanna Member, we believe that Butternut Member will eventually be extended westward to the Batavia Meridian. Since the Slate Rock bed interval is not seen west of the Francis Road locality, there is no way to distinguish Butternut-equivalent strata from underlying basinal facies in Erie County, it seems less likely that this term can be extended to that region (Fig. 5). However, black shale deposits observed below the Centerfield Member at Blossom on Buffalo Creek are almost certainly part of the Butternut-equivalent succession.

Levanna Divisions Erie County.

Lower calcareous mudrock division – Along Spring Creek south of Wende, Cayuga Creek in Lancaster, Slate Bottom Creek in Cheektowaga, Buffalo Creek by Indian Church Road, Cheektowaga, and Cazenovia Creek in West Seneca, is an interval of variably calcareous shale-mudstone facies with several concretionary limestone beds in the upper part. Along Buffalo Creek where this unit can be seen in its entirety, it includes 8.5 m of strata (Fig. 3). Fossils in this division are usually sparse but include auloporid corals, *Ambocoelia* and exuviae and occasional whole individuals of *Phacops rana*. We believe that this interval is the condensed, carbonate-enriched, cratonward equivalent of the Delphi Station Member minus an unknown thickness of strata eroded from the top (see below). The upper part of this unit will be seen at Buffalo Creek (STOP 6: Fig. 10).

Union Road disconformity – At Buffalo Creek and Slate Bottom Creek, the lower Levanna calcareous mudrock interval is abruptly overlain by a submarine disconformity (see Fig. 10: STOP 6). On Buffalo Creek, both beneath and immediately upstream from the Union Road overpass, this discontinuity separates underlying, gray calcareous mudrock facies from overlying fissile black to dark gray shale deposits. A significant transgression is indicated by the lithologic change, but the character of the contact itself is remarkable (Fig. 10). At Union Road, this discontinuity is characterized by numerous, parallel to subparallel, north-south-trending erosional runnels (Fig. 10). These 1.0-2.0 m side and 25 cm-50 cm-deep erosional channels are complexly filled with dark shale deposits which, in turn, may contain smaller nested channels. The bottoms of the larger channels contain lag concentrations of ambocoeliid brachiopods, *Phacops* exuviae and fish bones. Baird and Brett (1991) concluded that these channels represent ancient examples of submarine furrows, which are produced by sustained, unidirectional current erosion (Flood, 1983). Furrows occur in a variety of modern settings, but they are particularly common on the outer parts of continental shelves, often near the continental slope break. STOP 6, thus, affords a rare three-dimensional view of submarine erosive processes associated with transgressive onset of anoxic or minimally dysoxic conditions. At Slate Bottom Creek, this same contact is visible, except that no furrows are observed there (Fig. 9).

Undifferentiated medial and upper Levanna black shale division – Above the Union Road discontinuity on Buffalo Creek is approximately 27 m of very dark gray to black fissile shale which is overlain by the Centerfield Member (Figs. 3, 5, 10). From the Wende-Alden meridian westward to Lackawanna the medial and upper parts of the Levanna are represented by a facies succession that is distinctly more basinal than that further east; we believe that all of the Levanna succession above the Wadsworth Bed (and possibly above the base of the *Tasmanites*-rich shale unit) in the Genesee Valley grades westward into black shale (Figs. 5, 9). It is possible, if not probable, that the Slate Rock beds interval may persist into Erie County as a non-black facies unit, but no exposures of it exists there (Fig. 5). Thus, in Erie County, the Levanna is effectively two lithologic units, a lower calcareous mudstone division (Delphi Station Member-equivalent) and a higher division (Pompey Member-through-Butternut Member-equivalent succession).

Skaneateles Formation Unit Relationships: Central-Western New York Region

The Skaneateles Formation containing regionally mappable subdivisions represents a succession of outer shelf paleoenvironments ranging from near-anoxic and lower dysoxic (*Tasmanites*-rich shale unit, Butternut Member-equivalent black shale unit, medial-upper Levanna succession in Erie County) to fully oxic (parts of Stafford Member, Roanoke Bed, possibly Wadsworth Bed). It records stable outer shelf conditions, generally shallower than those indicated by the Union Springs and Oatka Creek formation-succession. Generally, there is an overall upward-deepening trend, starting with the relatively regressive Stafford Member and culminating with the top-Levanna (Butternut Member-equivalent) shale unit. Regionally, the Skaneateles Formation displays relatively shallower oxic and upper dysoxic facies at the Syracuse meridian, dysoxic to near-anoxic depocenter facies at the Cayuga Lake meridian, variably dysoxic to minimally oxic facies in Genesee Valley localities, and predominantly lower dysoxic to near-anoxic facies in Erie County.

The most prominent internal feature of the Levanna Member is the Union Road discontinuity which may represent significant erosional down cutting in Erie County

(Figs. 5, 9). This discontinuity may correlate with the Wadsworth Bed in the Genesee Valley-Batavia region. Further east, it may correlate with the "*Nyassa* Bed" (*Nyassa arguta*-rich siltstone layer recognized as the top of the Pompey Member by Cooper (1930) at the Pompey Member type section at Pratts' Falls near Pompey, New York) in central New York, but this is still unproven (Fig. 3). As seen with other contacts associated with black shale units, it appears to be most prominent where the overlying deposits become maximally basinal in character as in Erie County. This may be due to the effects of sediment-starvation and a combination of abrasive and corrosive bottom conditions associated with the base-Pompey Member-age transgression in that area.

TECTONIC AND EUSTATIC QUESTIONS

The various facies of the uppermost Onondaga Group-through Skaneateles Formation succession in western New York are most likely the result of eustatic rather than tectonic controls given the overall distance from the Acadian Orogeny, except for the great inferred regional deepening associated with onset of Bakoven black mud deposition which may be a partial result of viscoelastic lithosphere relaxation ("second tectophase") associated with thrust loading (see Ettensohn, 1985, 1987).

In this tectonic scenario, the Devonian foreland basin expands and deepens substantially accounting for the development of the Bakoven-through-Chittenango black shale succession. However, the enigmatic Halihan Hill Bed with its rich Hamilton fauna is observed to neatly separate the Berne Member (black shale) from the Chittenango Member (black shale) across almost the whole length of the State (Figs. 2, 3). Moreover, this bed yields a large-coral fauna in Hudson Valley localities and moderately shallow water taxa (*Tropidoleptus, Pseudoatrypa, Mediospirifer*, fenestrates, stereolasmatid rugosans) in localities to the west of there. As noted above, this thin unit produces the shallowest-water fossils observed between Onondaga and Centerfield strata in western New York, yet it is stratigraphically sandwiched within one of the most organic-rich black shale intervals in the east.

This pattern appears to contradict the concept of a thrust-loaded depression which should have relegated all associated basal Hamilton facies to a basinal anoxic-dysoxic facies range spectrum. Moreover, if the tectophase model were to apply here, one would perhaps expect that the Halihan Hill Bed might be a shallow water unit in western New York but be represented by significantly deeper water facies and thicker deposits in eastern New York more proximal to thrusts. If tectonic loading was truly operating at that time, thrust loading would have been essentially restricted to the New England and Hudson Valley regions with the foreland basin constrained to an area largely east of New York State. This would better explain the lack of major sediment input during the Halihan Hill eustatic lowstand. Otherwise, the significant eustatic lowstand, suggested by Halihan Hill Bed facies, would have produced a major progradational pulse timed with this unit if the thrust-load basin was centered west of the Catskill front at this time.

Applying the terminology of sequence stratigraphy to divisions discussed here, it can be argued that the upper Onondaga Group generally comprises a transgressive systems tract with development of high energy, proximal facies (Moorehouse Member) in the middle Onondaga and mid to outer-shelf deposits (Seneca Member) at the top (see Brett and Ver Straeten, 1994). The Bakoven black shale deposit, marks a major eustatic (and partially tectonic?) highstand event with the top-Seneca Member corrosional discontinuity marking a maximum flooding surface (Brett and Ver Straeten, 1994; Ver Straeten, et al., 1994). Most of the Stony Hollow Member constitutes a regressive or late highstand systems tract while the Cherry Valley Member marks the transgressive systems tract of the next major sequence. The Chestnut Street submember, correlative to the uppermost part of the Stony Hollow, is believed to rest on a regional (4^{th} order) sequence boundary unconformity (Ver Straeten et al., 1994). The Cherry Valley-Berne contact, marked by a corrosional discontinuity in western New York is a maximum flooding surface contact overlain by early highstand facies of the Berne Member.

The Berne-Halihan Hill contact apparently represents another major (4^{th} order) sequence boundary, though no obvious erosional lag features (phosphatic pebbles, reworked concretions, scour channels) are observed at its base. In essence, the Halihan Hill Bed may be a rare example of condensed proximal facies in a sediment-starved regime. Major southeastward thickening and moderate coarsening of the Berne Member in eastern New York suggests that the Halihan Hill Bed may have "ridden over" a major progradational regressive systems tract succession east of the current Devonian outcrop limit. If so, it would constitute an initial transgressive systems tract succession. Black Chittenango facies above the Halihan Hill Bed represent early highstand deposits, perhaps accentuated by tectonic thrust loading. A 1 cm-thick shell hash layer rich in orbiculoid shell fragments within the lower Chittenango (0.8 m above the Halihan Hill Bed on Oatka Creek, STOP 3b) may represent a maximum flooding surface or a separate event.

The Stafford –Mottville succession marks the end of another widespread regression perhaps comparable to but not as prominent as that of the Halihan Hill. Recent examination of Mottville sections near Syracuse by the present authors show that the actual regression and progradation event is represented by the Mottville "sub-A" deposit. An erosional sequence boundary unconformity is present beneath the Mottville "A Bed" encrinite of Grasso (1986). Hence, the Mottville "A: and all higher Mottville layers are part of a transgressive systems tract succession. Although the exact position of the "A" Bed is somewhat uncertain for western New York Stafford sections, we believe it is at or near the base of the Stafford main limestone bed at LeRoy (Stop 3c).

The Levanna Member records a succession of transgressive-regressive cycles. As noted above, the Cole Hill cycle, Delphi Station cycle, the Pompey and "Marietta" cycles and the Butternut-Chenango cycle of central New York (Grasso, 1986; Linsley, 1991) all connect to various beds and intervals in the western New York Levanna succession. As of this writing, maximum flooding events associated with the basal Pompey ("*Tasmanites* Shale" interval), top-Pompey (Wadsworth Bed and Union Road disconformity), and base-Butternut contact are the most conspicuous tie lines observed in the Levanna. Confirmation of correlation of these and lesser markers to central New York coarsening-up cycles is the goal of our ongoing work.

ACKNOWLEDGMENTS

We are particularly grateful for the tireless effort of Denice Tollison who typed drafts of this paper during its preparation. Lisa Trump provided critical assistance in preparing the line drawings. Our work on the Levanna Member was supported by grants from the Petroleum Research Fund and NSF EAR 9219807.

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ROAD LOG

Leave SUNY Fredonia and proceed to I-90 Dunkirk interchange. Proceed east on I-90 (NYS Thruway) past Buffalo towards Rochester. We begin the field trip road log at the junction of I-90 and I-390 south of Rochester where we exit I-90 (NYS Thruway) onto I-390 and proceed south.

0.0	0.0	Enter I-390 (southbound)
0.15	0.15	Cross I-90
3.2	3.05	Exit I-390 onto U.S. Route 15 Southbound
7.25	4.05	Route 15 passes over I-390
7.45	0.2	Intersection (yellow blinking light) of Route 15 and Honeoye Fall #6 Road. Turn left (east) onto Honeoye Fall #6 Road
7.6	0.15	Cross over I-390; view of three drumlins to the right (south)
9.3	1.7	Five Points Road on left; continue straight ahead
10.2	0.9	Cross Works Road; small outcrop of Onondaga Limestone on right along Works Road.
10.9	0.7	Entrance to General Crushed Stone Corporation, Honeoye Falls quarry, at Town of Mendon line; <u>turn right</u> into entrance and <u>bear right</u>.
11.1	0.2	Quarry Office: stop and check in <u>General Crushed Stone Quarry, Honeoye Falls Plant</u> (Five Points Quarry).
11.1	0.0	Turn left (south) onto main quarry road and proceed past high tanks towards old equipment area onto narrow road along north rim of quarry.
11.7	0.6	Fork of lower and higher quarry roads.
11.75	0.05	Enter higher road onto top of Onondaga Limestone and park.

STOP 1: General Crushed Stone Quarry, Honeoye Falls Plant. Quarry north-northwest of Lima, New York (RUSH 7.5' Quadrangle). Pit is located on south side of Honeoye Falls #6 Road, 6 km (3.4 mi) east of the Honeoye Falls #6 Road/Route 15 intersection. PERMISSION TO ENTER QUARRY MUST BE OBTAINED BEFORE ENTERING. Hardhats required!!!

This is a classic exposure of the Onondaga Limestone and the basal portion of the Hamilton Group (see extensive treatment by Brett and Ver Straeten, 1994; Ver Straeten et al. 1994). We will proceed southeastward on foot from the quarry road terminus at the southwest edge of the pit along the conspicuously sloped next-to-top riser. Note the exceptional jointing of the limestone at various quarry levels and the southward dip throughout which is steeper than the 0.5° average for the region. The riser on which we walk is developed on the top-contact of the Moorehouse Member of the Onondaga; choice of this horizon as a staging surface in the quarry probably relates to the position of the soft Onondaga Indian Nation (OIN) K-bentonite which allowed for easy peel-back of overlying beds. This ash is 25 cm-thick at this locality. The OIN K-bentonite is the thickest of a series of closely-spaced ash beds known as the "Tioga Ash Complex" in literature (Conkin, J.E. and B.M. Conkin, 1984; Rickard, 1984). Dennison and Textoris (1978) believe that "Tioga" tuffs originated in what is now northern Virginia and the prevailing paleowinds carried the volcanic products predominately westward (in the present sense) into the U.S. midwest. Several higher, thinner K-bentonites can be seen in the Seneca Member (quarry wall above OIN position) as reentrants. Some of these are associated with chert bands (see discussion of Ver Straeten et al., 1994) of detailed ash succession (Fig. 4).

Crinoidal, brachiopod-rich limestone marking the top of the Seneca Member is abruptly succeeded by the Bakoven Member where a 2-3 mm-thick black shale bed is draped upon a minor discontinuity at the top of the Onondaga (Fig. 4). This is, in turn succeeded by a 15 cm-thick K-bentonite layer (Tioga F Ash) and platy styliolinid-rich limestones that overlie the ash. Within the interval of styliolinid limestones is a bone bed rich in onychodid teeth, arthrodire dermal armor and conodonts. Very large specimens of *Panenka*, a bivalve typical of dysoxic facies, occur within the styliolinid limestone interval as well. Succeeding Bakoven strata are composed of platy black shale facies (Fig. 4). In this quarry, the Bakoven Member ranges from1.7 m to as little as 7 cm in thickness due to variable truncation below the sub-Cherry Valley unconformity (Ver Straeten et al., 1994).

The Chestnut Street submember of the Hurley Member is only locally exposed in this quarry (Fig. 4); it is expressed as a light weathering richly fossiliferous limestone bed at the eastern end of the exposure. The proetid trilobite *Dechenella haldemanni*, auloporids, sponge spicules and diminutive calyces of the crinoid *Haplocrinites* are characteristic fossils. Removal of almost all of the Chestnut Street bed and all post-Chestnut Street Bed Hurley strata reflects channelized downcutting associated with a disconformity at the base of the Cherry Valley Limestone (Ver Straeten et al., 1994).

The Cherry Valley Member of the Oatka Creek Formation is represented by 0.4 to 3.0+ meters of crinoidal pack-and grainstone carbonate containing lesser amounts of styliolinid and fenestrate allochems. Major variation in Cherry Valley thickness at this locality apparently reflects paleorelief at the base of the unit owing to the presence of paleochannels associated with differential erosion of the Bakoven Shale (Ver Straeten et al., 1994). Sparse conchs of the characteristic goniatite *Agoniatites* and the orthoconic cephalopod *Striacoceras* have been found at this locality. A pyrite coated corrosional discontinuity marks the contact between the Cherry Valley limestone and overlying black shale facies of the Berne Member of the Oatka Creek formation (Fig. 4). At last visit about 1.5 m of this shale was exposed below till at the uppermost bedrock limit; to date, the Halihan Hill Bed has not been uncovered in this section.

The Honeoye Falls quarry section is significant in that it displays the westernmost occurrences of the Bakoven Shale, Chestnut Street submember, and Cherry Valley Limestone that can be seen in outcrop (Figs. 4, 5). At STOP 3a, the Berne Member is juxtaposed directly onto the Seneca Member with development of a composite unconformity between them (Figs. 5, 6). STOP 1 is significant in showing no less than four discontinuities: base-Bakoven, lower-Bakoven, sub-Cherry Valley, and sub-Berne contacts that ultimately contribute to the large composite hiatus at LeRoy.

Return to cars and retrace route to quarry entrance.

12.6	0.85	Turn left (west) onto Honeoye Falls #6 Road. Retrace route back to Honeoye Falls #6/Route 15 intersection.
16.05	3.45	Turn left (south) onto Route 15 at yellow blinking light.
16.55	0.5	Enter Livingston County
18.8	2.25	Intersection of Route 15 and U.S. Route 20 in Village of East Avon. Continue straight (south).
21.4	2.6	Junction of Route 15 with Ager Road. Turn right (west) onto Ager Road.
22.75	1.35	Junction of Ager Road and Pole Bridge Road. Turn left (south) onto Pole Bridge Road (we will be on this only momentarily).
22.8	0.05	Junction of Pole Bridge Road and Paper Mill Road. Turn right (west) onto Paper Mill Road.
24.0	1.2	Cross over Conesus Creek and make immediate right turn into small park at creek.

STOP 2: Levanna Shale Member. Type section of Papermill Limestone and associated beds of uppermost part of Delphi Station-equivalent Levanna (see Fig. 9).

The footbridge over the creek near the parking area, provides a good look at the resistant limestone ledge of the Papermill Bid. This unit was misidentified as Stafford in early literature. At this locality, the Papermill is composed of bioturbated mudstone characterized by few fossils. The most notable bed content consists of three-dimensional barite infilled orthoconic cepholopods and infrequent clumps and masses of barite. The top of the Papermill Bed near the foundation of the Paper Mill Road overpass is marked by a thin bed of auloporid corals and other fossils (Fig. 9); this is the Roanoke Bed which is better developed at STOP 4 (Fig. 8). Upstream from the Paper Mill Road bridge are good exposures of both Pole Bridge Limestone layers and still further upstream is good development of the Wadsworth Bed (see text). The upward succession of Papermill Bed-lower Pole Bridge Bed-upper Pole Bridge Bed-"*Tasmanites* Shale" interval marks a stepwise overall marine deepening that marks the change from upper Delphi Station lowstand conditions to basal Pompey cycle highstand facies (see text).

		Return to cars and exit park. Turn right (west) onto Paper Mill Road.
24.4	0.4	Junction of Paper Mill Road and Route 39. Turn right (north) onto Route 39.
26.2	1.8	Cross Conesus Creek at Ashantee. Onondaga Limestone (Seneca Member) is exposed both below and above Route 39 bridge.
27.5	1.3	Route 39 intersection with combined Routes 5 and 20 in Avon. Turn left (west) onto Route 20.
27.9	0.4	Leave Village of Avon.
28.0	0.1	Bridge over Genesee River
28.4	0.4	U.S. Route 20 forks from Route 5. Bear right on Route 5 and proceed northwest to Caledonia.
29.1	0.7	Leave Genesee River floodplain.
33.8	4.7	Enter Village of Caledonia
34.5	0.7	Center of Caledonia; Route 36 merges in from the right; turn left (west).
34.7	0.2	Route 36 splits off from Route 5. Continue on Route 5.
35.35	0.65	Leave Village of Caledonia.
37.35	2.0	Leave Livingston County; enter Genesee County.
38.45	1.1	Pass through Limerock. Proceed towards LeRoy; route passes south of 5 to six large quarries developed into the Onondaga Limestone.
40.65	2.2	Enter Village of LeRoy.
41.45	0.8	Cross over Oatka Creek; falls over Stafford Limestone immediately north of bridge.
41.5	0.05	Turn right (north) onto Mill Street from Route 5.

41.95 0.45 Turn right from Mill Street into parking pull off by Oatka Creek immediately north of railroad overpass and where Mill Street turns west. Proceed on foot to creek edge.

STOP 3: Bed of Oatka Creek north of (downstream from) Route 5 in town of LeRoy (LeRoy 7.5' Quadrangle). Creek parallels small park along Mill Street. Outcrop floors creek between falls over Stafford Member near dam and railway bridge to the north of a park footbridge over creek (Fig. 6).

This section offers a variably accessible but nearly continuous section from the uppermost Seneca Member up to the Stafford Limestone (Fig. 6). We will first park in the northernmost parking area where Mill Street turns west immediately north of the railroad overpass (STOP 3a). We will then drive south past two houses and a footbridge to the next park pull-off to the south of STOP 3a (STOP 3b) and finally to the main parking area near the southern end of Mill Street (STOP 3c). Proceed on foot from 3a pull off to edge of creek.

STOP 3a: Halihan Hill Bed and basal Chittenango Member of the Oatka Creek Formation.

Although the Seneca Member-Berne Member composite unconformity was excavated by Baird on this creek in the mid 1980s, the contact is currently concealed by debris. However, one can sample richly fossiliferous Seneca facies just below the contact level on this creek at the present time. The sub-Berne disconformity is expressed as a pyrite-coated irregular, pitted surface with phosphatic lag debris in depressions on the contact (Baird and Brett, 1991). The Berne Member is poorly exposed below water to the north of our access point (Fig. 6). This 40 cm-thick unit is composed of black shale rich in large styliolinids.

At this section, the Halihan Hill Bed is also exposed below water (Fig. 6). However, the upper part of this unit is within the reach of hammers if the water is not high. The 60 cm Halihan Hill interval is composed of very soft, gray shale which yields diverse and abundant fossils. Key brachiopods at this locality include *Mediospirifer audaculus, Athyris cora, Tropidoleptus sp., Devonochonetes sp., Ambocoelia umbonata, Pseudoatrypa devoniana.* Other fossils include stereolasmatid corals, encrusting, bifoliate and fenestrate bryozoans, pteriomorph bivalves, *Phacops* exuviae and pelmatozoan debris. The bed marks the dramatic appearance of the Hamilton macrofauna that holds sway in the study area for most of the Givetian Stage.

Return to vehicles. Turn left (south) and proceed along Mill Street.

42.05 0.1 Turn left onto park pull-off south of footbridge over Oatka Creek. Proceed on foot to creek.

STOP 3b: Black, organic-rich shale deposits of the Chittenango Member of the Oatka Creek Formation.

This brief stop serves to illustrate the exceptionally organic-rich facies of the Chittenango Member. Well jointed, very hard black shale is exposed in the creek bed. This part of the Chittenango displays T.O.C. values exceeding 15%. Although no macrofauna is observed in this facies, a thin (1 cm-thick) debris layer of orbiculoid fragments is observed in the lower Chittenango in the vicinity of the park pull-off.

Return to vehicles. Turn left (south) and proceed along Mill Street.

42.35 0.3 Turn left into large parking area near south end of street and proceed on foot to platform near falls.

STOP 3c: Stafford Limestone Member of Skaneateles Formation and uppermost strata (Chittenango Shale Member) of Oatka Creek Formation exposed in waterfall below dam. Section easily viewed from viewing platform by parking lot (Fig. 6).

Below the conspicuous Stafford limestone ledge are several feet of black to dark gray fissile shale assignable to the Chittenango Member. Some of the highest beds are not as black and organic rich as typical Chittenango. Moreover, they yield flattened rhynchonellids and orbiculoids below the base-Stafford contact. Although not formally used here, the term "Cardiff Shale" is marginally applicable to these beds (see above). Further east in the vicinity of Skaneateles, the upper part of the Chittenango transforms eastward into gray, fissile shale that has been formally assigned to Cardiff.

At this section 78 cm of Stafford Member, including a lower calcareous dark gray shale interval and 28 cm of resistant limestone, are present in the falls. The uppermost calcareous shale portion of Stafford is concealed here. As with other Stafford sections in the Waterloo-Stafford region, the member is thin and distinctly condensed. Unlike sections in Erie County (Meyer, 1985) and in Onondaga and Madison Counties (Grasso, 1986), where two prominent ledges ("A" and "B" beds) respectively characterize Stafford and Mottville sections, the LeRoy Stafford section is characterized by a single limestone unit underlain by a brachiopod-rich shale unit (Fig. 6). The shale interval below the limestone is typically characterized by abundant *Ambocoelia* and *Devonochoneaes*. The falls-capping limestone bed contains *Camarotoechia sappho, Bembexia sulcomarginata,* occasional small rugosans, auloporids and uncrushed orthoconic nautiloids. The matrix is a brownish gray wackestone lithology, fossils are typically three dimensional and mollusc shell is expressed as sparry black calcite.

Due to the thinness and minimal differentiation of the limestone part of the Stafford in this area, it is difficult to connect the "A" and "B" bed terminology of Meyer (1985) for Erie County and the "A" and "B" bed-usage of Grasso (1986) for Onondaga County (see text). We suspect that the regressive lowstand marked by a scour surface at the base of Grasso's "A" bed encrinite in Onondaga County roughly links to the base of the limestone bed at LeRoy, but this is, as yet, unproven.

Return to vehicles; turn left (south) out of parking lot.

42.4	0.05	Junction of Mill Street with Route 5; turn right (west) onto Route 5.
42.55	0.15	Junction of Route 5 and Route 19; continue straight.
43.25	0.7	Leave Village of LeRoy.
43.4	0.15	Junction of Route 5 and Bethany-LeRoy Road; turn left (south) onto Bethany-LeRoy Road.
46.2	2.8	Junction of Bethany-LeRoy Road with Covell Road. Turn left (south) onto Covell Road.
46.4	0.2	Cross Oatka Creek
46.42	0.02	Turn left into driveway immediately south of Covell Road bridge and proceed to house at end of driveway. This is PRIVATE PROPERTY. Permission to enter must be obtained from the owner.
46.55	0.13	Park vehicles and proceed to edge of creek.

STOP 4: Levanna Shale Member of Skaneateles Formation (Fig. 8).

This exposure shows Papermill Limestone Bed, Roanoke Bed, probable "*Tasmanites* Shale" with subjacent diastem, Wadsworth Bed, and an overlying unnamed shale unit in the upper Levanna (see text). The exposure is partly below water in bed of Oatka Creek 200-250 m east of (downstream from) Covell Road overpass (Stafford 7.5' Quadrangle). The outcrop is 6 km (3.5 mi) southwest of LeRoy, NY. We will access outcrop by entering through a private driveway exiting off of road immediately south of the creek that terminates at a residence near the exposure.

Several key Levanna beds occur in this section nearly juxtaposed on one another (Fig. 8). At the northeast (downstream) end of the section, is the Papermill Bed, a 0.7 m-thick massive limestone marker in the upper-middle part of the Levanna. This unit, yielding few fossils, marks one of the highest levels in that portion of Levanna that we believe is equivalent to the Delphi Station Member (see text: Fig. 8). Above the Papermill ledge is a 25 cm-thick interval of profusely fossiliferous, soft, gray mudstone yielding thicket growths of a large variety of *Aulocystis* (Fig. 8). This mudstone unit, herein designated the Roanoke Bed with this locality as its type section (see text), is mostly exposed below water. On Oatka Creek, this bed is thickest and best developed; the *Aulocystis* thicket layer yields brachiopods such as *Pseudoatrypa* and *Rhipidomella* and crinoid debris is abundant. Above the thicket layer is a 0-10 cm thick interval of soft gray mudstone yielding *Arthracantha* fragments and large *Phacops*. This unit marks the faunal acme of the entire Levanna in this region; it probably marks a sea level lowstand coincident with a maximally regressive part of the Delphi Station cycle in central New York (see text).

At STOP 4, the Roanoke Bed is abruptly and unconformably succeeded by a 40 cm-thick interval of fissile, dark gray to near black shale (Fig. 8). The Roanoke-black shale boundary is knife-sharp and it is marked by abundant reworked pyritic burrow tube fragments. These fragments, derived from in-situ pyritic burrow networks in the Roanoke Bed, locally show a weak current alignment. The tubes are identical to those observed in the Leicester Pyrite Member and in higher Genesee Formation levels; we believe that they were exhumed under dysoxic to near-anoxic conditions, most likely by bottom current processes or the shoaling of internal waves (Baird and Brett, 1991). Also significant is the scarcity of carbonate allochems associated with the tubes despite the abundance of carbonate fossils in the Roanoke. Baird and Brett (1991) argued that under lower dysoxic to near-anoxic bottom conditions, reworked pyrite could remain unoxidized when exposed to the sea bed while carbonate allochems would undergo dissolution. This reversal of the normal oxic situation could explain the lack of carbonate in detrital pyrite-dominated lags. The black shale above the discontinuity yields flattened rhynchonellids ("*Leiorcynchus*") and abundant *Tasmanites*. We believe that this unit is a beveled remnant of a thicker organic rich unit ("*Tasmanites* Shale") observed in the Genesee Valley (Fig. 9).

Above the dark shale unit is a 8-10 cm-thick bed marked by abundant fossils (Fig. 8). This is the Wadsworth Bed that is composed of a muddy hash of small brachiopods (*Devonochonetes, Ambocoelia*), minor pelmatozoan debris, auloporid thicket and debris fabric and *Tasmanites* set in a network of *Thallasinoides* burrows (see text). Conodonts and small fish bones and teeth are also present in this bed, though less conspicuous than at the base of the black shale. These are commonest in burrows at the base of the bed; their distribution suggests that the base of the unit is erosional and that this erosion explains the anomalous thinness of the underlying black "*Tasmanites*" Shale unit. This unit can be traced into the Genesee Valley, but only tentatively east of there (Fig. 9); it may correlate to the *Nyassa arguta*-rich sandstone at the top of the Pompey Member in central New York (see text). To the west it may connect to the Union Road discontinuity that we will see at STOP 6.

Above the Wadsworth Bed is a monotonous interval of dark gray fissile shale that is visible in the upstream, north-facing shale bank. These shales yield a sparse biota of *Devonochontes scitulus,* flattened rhynchonellids ("*Leiorhynchus*"), small Ambocoeliids and diminutive gastropods and bivalves. Based on correlations to date, we are involved in ongoing efforts to determine whether this unit is part of the Pompey or the next higher "Marietta Cycle" (see text).

Return to vehicles and retrace route back to Covell Road/Bethany-LeRoy Road intersection.

46.9 0.35 Turn left (west) onto Bethany-LeRoy Road.

47.55 0.65 Intersection of Roanoke Road and Bethany-LeRoy Road in Hamlet of Roanoke. Continue straight on Bethany-LeRoy Road.

50.15	2.6	Junction of Bethany-LeRoy Road and Route 63; turn left (southeast) onto Route 63.
50.4	0.25	Intersection of East Road and Route 63; turn right (west) onto East Road. East Road curves around to the south in a 0.25 mi distance.
51.65	1.25	Intersection of East Road and Jericho Road; continue straight (south) on East Road. Small exposure of Kashong Shale on East Road north of Intersection.
52.2	0.55	Intersection of East Road and U.S. Route 20. Turn right (west) on Route 20.
53.7	1.5	Exposure of Genundewa Limestone Member of the Genesee Formation (Upper Devonian: lower Frasnian) on left (south) side of Route 20 beneath Bethany Center Road overpass. The Genundewa is a styliolinid-rich limestone rich in cephalopod conchs at this locality and, along with the Cherry Valley Member is a classic cephalopod limestone.
		Proceed west on U.S. Route 20 through towns of Alexander, Darien, Darien Center and Alden. Not much geology is visible from Route 20 over this 25 mile distance, though numerous classic upper Hamilton Group localities occur near the read in this area.
79.2	25.5	Cross Bowen Road/Route 20 intersection near the approximate east edge of the Town of Lancaster, Erie County.
80.35	1.15	Turn left (south) off of Route 20 onto Church Street.
80.65	0.3	Cross Pardee Road into Como Park pull-off. Proceed on foot to outcrops on Cayuga Creek in park.

STOP 5 (optional): "A Bed" at base of Middle Devonian Stafford Limestone Member at Como Park (Fig. 7).

Along the banks and bed of Cayuga Creek between the dam and base of the small waterfalls lip at the Lake Avenue bridge are exposures of the Stafford Limestone Member, the basal division of the Skaneateles Formation (Fig. 7). Downstream from the waterfalls are intermittent exposures of the black, fissile, organic-rich Chittenango Member of the underlying Oatka Creek Formation which is mostly covered. Near the falls and bridge, the topmost few feet of the Chittenango Shale can be examined on the south side of the creek; these uppermost Oatka Creek beds are dark gray-brown in color and they yield a meager dysoxic biota consisting of flattened rhynchonellids ("*Leiorhynchus*"), *Styliolina*, and numerous flattened composite molds of an orthoconic nautiloid.

The Stafford, in Erie County, is a four-part member consisting of a basal, thin, shell-rich muddy limestone bed ("Sub-A" bed), a slightly higher limestone unit with encrinite at its base (probable "A" bed of central New York Mottville), a middle, shaley interval several feet thick which contains nodular, micritic, concretionary beds, and a fossiliferous upper cherty limestone division, termed the Stafford "B" bed, which is 0.6-1.3 m (2 to 4 feet) in thickness (see Meyer, 1985). In central New York, the equivalent Mottville Member starts with a fossiliferous, calcareous mudstone division ("sub-A" bed) followed by an encrinite-rich "A" bed limestone ledge, which is succeeded, in turn, by a variably-thick middle "shale" division followed by a micritic or siltstone regressive capping unit which corresponds to the Erie County, chert-rich ("B") micritic division visible by the Como Park dam (see text). The "sub-A" bed remains relatively thin, usually between 8 and 30 cm (0.2-1.0 feet) in thickness in this area, and it is typically a densely fossiliferous calcareous mudstone, both overlain and underlain by sparsely fossiliferous deposits (Fig. 7). The "sub-A" bed typically rests abruptly on dysoxic to anoxic dark shales. The "middle shale" usually grades upward into fossil-rich shaley micrites of the "B" bed.

At this locality the Stafford "sub-A" bed yields numerous small brachiopods, including *Crurispina nana, Truncalosia truncata, Devonochonetes scitulus*, and a small variety of *Tropidoleptus*. Other fossils include the large bivalve *Panenka*, occasional *Camarotoechia*, orthoconic nautiloids often encrusted by the reptate biserial tubular organism *Reptaria stolonifera*, which may have "hitchhiked" on the living cephalopod (see Baird et al., 1989), and wood debris. The diminutive brachiopod assemblage in the Stafford "sub-A" bed appears to represent only a slight increase in bottom oxygenation relative to the underlying Oatka Creek Shale. This assemblage falls between the "*Leiorhynchus*" and "*Ambocoelia*-chonetid" biofacies of Brett et al., 1986; Vogel et al., 1986; which is indicative of non-turbid upper dysoxic to minimally oxic bottom conditions (see text).

Return to vehicles. Turn left (west) on to Pardee Avenue.

80.7	0.05	Junction of Old Lake Avenue with Pardee Avenue. Bear right (northwest) onto Old Lake Avenue.
80.75	0.05	Junction of Lake Avenue with Old Lake Avenue. Turn right (north) on to Lake Avenue.
81.0	0.25	Junction of Route 20 and Lake Avenue. Turn left (west) onto Route 20.
81.3	0.3	Cross Cayuga Creek. Middle Devonian black and dark gray shales of the Chittenango Member are intermittently exposed along creek in this area.
81.8	0.5	Leave Town of Lancaster, NY.
81.9	0.1	Cross Cayuga Creek.
82.5	0.6	Junction of Transit Road (U.S. Route 20) with Broadway (Route 130).

Continue straight (west) on Broadway (Route 130).

83.0	0.5	Junction of Broadway with Rowley Road (to left). Two excellent exposures of the upper part of the Onondaga Limestone with associated Tioga ash beds are respectively developed on Cayuga Creek adjacent to the road 0.5 and 1.5 miles west-southwest of the Broadway/Rowley Road intersection (Brett and Baird, 1990). We will continue west on Broadway.
84.1	1.1	Leave Town of Depew.
85.5	1.4	Junction of Union Road with Broadway; turn left (south) on to Union Road.
86.7	1.2	Cross Cayuga Creek. Middle Devonian Onondaga Limestone is exposed both below bridge and upstream from it.
88.0	1.3	Leave Town of Cheektowaga.
88.7	0.7	Cross Buffalo Creek. Excellent exposure of Levanna Member that we will examine is developed below bridge.
88.8	0.1	Turn left off of Union Road into small parking area immediately south of one-way exiting street. Park vehicles and proceed north across one-way road through area designated for a new town park (Burchfield Park) to edge of Buffalo Creek.

STOP 6. Submarine Discontinuity (Union Road disconformity) within Middle Devonian Levanna Shale Member along Buffalo Creek (Figs. 9, 10).

Along this cutbank exposure one can observe two key Levanna lithologic divisions which are currently unnamed. Just above water level is a calcareous, dark gray-shale division which yields the diminutive brachiopod *Ambocoelia* and specimens (many complete) of the trilobite *Phacops rana*. A submarine discontinuity (prominent undulatory outcrop reentrant) separates this lower unit from a fissile, black shale upper division, rich in flattened rhynchonellids ("*Leiorhynchus*") and *Styliolina*. This boundary is probably correlative with the Wadsworth Bed in the Black Creek-Conesus Creek area (Figs. 5, 9). The units in this section record oxygen-deficient outer shelf-to-basin conditions with the lower division recording dysoxic to minimally oxic conditions and the upper division recording lower dysoxic to near-anoxic conditions ("exaerobic" zone of Savrda and Bottjer, 1987) along the seabed.

This discontinuity is distinctive for its distinctly undulatory appearance; troughs between 0.5 and 2.0 m (1.5-6.5 feet) in width and between 12 and 45 cm (5 to 16 in) in depth alternate with intertrough ridges and platforms (Fig. 10). The troughs are erosional runnels cut into division 1 deposits which are aligned in a nearly north-south direction transverse to the creek channel (Fig. 10B). Some runnels bifurcate but most remain simple and linear. Trough bottom deposits often include calcareous brachiopods, *Phacops*, and *Styliolina* debris admixed with fish teeth and dermal plates. These lags are commonly at channel bottoms but they can occur in axial channel sediments above channel bottoms. Some troughs appear to have been repeatedly filled with sediment and scoured out by currents; these troughs display nested erosional scour surfaces with the sharpness of scour contacts varying from clear to diffuse (Fig. 10C). Evidently some episodes of scour removed only water-rich surface mud while others cut into firm muds.

Clearly, this section records a type of sedimentary condensation where repeated sediment accumulation and scour were dominant sedimentary processes. The overall upward-change across the disconformity appears to be transgressive with the consequent development of an erosional surface; the complex channel-fills appear to correspond to the interval of maximum sediment-starvation and sedimentary condensation which overlies the transgressive erosion surface.

These erosional runnels are probably submarine furrows (see Flood, 1983), which are rarely reported from the stratigraphic record. Furrows are believed to form through the action of abrasive horizontal, debris-laden current vortices which scour the bottom into linear runnels within a sustained unidirectional current regime (Flood, 1983). The complex "cut-and-fill" histories of the Levanna runnels is a testament to the unidirectional character of the currents which produced them. We are currently studying these features at this locality to establish which way the currents flowed and are also examining all other similar discontinuities to determine if similar runnels are distributed along them.

Return to vehicles. Turn right (north) onto Union Road and cross Buffalo Creek (traffic is heavy on Union Road; we will have to turn around at the intersection of Union Road and Route 354 just north of Buffalo Creek in Gardenville. The road log commences again at the Union Road bridge over Buffalo Creek once we have completed the U-turn).

89.05	0.25	Cross Buffalo Creek.
89.8	0.75	Entrance ramp to Route 400. Bear right on to ramp and proceed west on Route 400.
91.5	1.7	Entrance ramp to I-90 (southbound). Continue around cloverleaf and proceed to Fredonia.

END OF ROAD LOG